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Tough lightweight fiber systems combined with preform framing are allowing for new innovations in durable lightweight boat structures for US Navy Combatant Craft. Designs utilizing this new technology offer weight savings potential of 40% to 60% when compared to conventional construction. Structural weight savings and shock mitigation have been demonstrated by combining lightweight membrane hull laminate and suspended cockpits. The single skin membrane structure reduces weight and absorbs wave impact energy though panel deflection. The suspended cockpit further mitigates shock due to wave impact as the deck is allowed to move relative to the hull. The project also provides for research into the effects of pressurizing the hull to deck cavity. The results of two demonstration craft, 8.5 m and 11 m are presented in this paper.

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Executive Summary

Successful execution of the maritime strategy requires not only front line surface combatants, but also the acquisition and construction of numerous high performance boats and craft for the U.S. Navy and other DoD and Government agencies. In 2009, the Auxiliary Ships, Small Boats and Craft program office (PMS 325) in the Program Executive Office, Ships (PEO Ships) delivered more than 270 boats and combatant craft to Navy commands, Domestic agencies and Allied Nations. Current domestic acquisitions include rigid inflatable boats (RIB), riverine assault, command and patrol boats, force protection boats, fleet harbor security boats and service craft for U.S. installations worldwide. Under PMS 325, the Navy's combatant craft division (CCD) supports more than 10,000 boats, craft and life rafts world-wide. The group supports the US Navy, Army, Marine Corps, Naval Special Warfare, Air Force, Coast Guard and other DoD activities.

As low intensity conflicts increase on a global basis, our Armed forces are becoming increasingly dependent on small combatant craft. These high speed platforms are improving mission capabilities and helping to reduce risk for security and armed forces. The range of missions and demands on combatant craft are ever increasing. Larger payloads, longer duration missions and missions that subject crew to ballistic threats are increasing the cost and weight of the craft. These same mission drivers that increase weight are decreasing craft performance thus subjecting the crew and asset to greater risk. New small and medium craft are needed to meet the increasing requirements placed on surface combatant craft. Rigid Inflatable Boats (RIB), developed over 40 years ago, are typically glass fiber reinforced plastic (GFRP) hulls with an inflatable collar. They range in size from 5M, 7M, 8M, 9M and 11M in length. RIBs are used to support a variety of missions including Force Protection, Harbor Security, Standard Ship Boats, Dive Support and Special Forces insertion/extractions. Light weight, durable, easily transportable boats are critical for mission success.

This program developed manufacturing technology and systems to provide lightweight, high performance, affordable RIBs to meet the ever increasing mission requirements.

A manufacturing technology system was developed that combines advanced materials and composite manufacturing technology to produce lightweight, robust and affordable Rigid Inflatable Boats. In addition to significant weight reduction, the program has validated an innovative design that mitigates the damaging effects of wave impacts on operators and crew.

The program fabricated and tested two prototype craft. An 8.5M craft that had a 40% reduction in hull and deck weight was fabricated, outfitted, and field tested, and an 11M craft with a 37% reduction in hull and deck weight was fabricated and drop tested.

The results of the effort demonstrate that the technology can deliver significant weight reductions and performance enhancements. The craft also demonstrate that decoupling the hull

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and deck structure results in a significant reduction in the peak G loads observed at the deck vs. the hull of the craft during wave impact events.

The manufacturing trials and studies indicate that the significant weight and performance enhancements do not result in a significant increase in cost. Material cost savings are offset by higher labor costs associated with moving from the open mold wet layup process to the more advanced and sustainable infusion manufacturing process.

The project has advanced the technology to TRL7 for the 8.5M craft and to TRL5 for the 11M Craft. Further efforts are needed to transition the technology to implementation. These include fabricating and qualifying a TRL8 8.5M craft and completing the build out, testing and evaluation of the 11M composite structure produced and drop tested in this effort.

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Table of Contents

Executive Summary 2
1.0 Introduction/Summary 11
2.0 Background/Problem Statement 13
3.0 Objectives 14
4.0 Approach 14
4.1 Statement of Work 17
5.0 Results and Discussion 20
5.1 Preliminary Testing 20
5.1.1 Mechanical Properties Tests 20
5.1.2 Water Absorption Testing 22
5.1.3 Additional Water Absorption Testing 23
5.1.4 Coatings Evaluations – Mechanical Properties 27
5.1.5 Coatings Evaluations – Biofouling 31
5.1.6 Creep Tests 37
5.1.7 Resin Workability 41
5.2 850 Designs 42
5.2.1 850A Design 42
5.2.2 850B Design 46
5.3 850B Manufacturing 56
5.4 850B Craft Performance Evaluations 64
5.4.1 850B Instrumentation and Sensor Locations 64
5.4.2 850B Loading Conditions 68
5.4.3 850B In-Water Trials 69
5.4.4 850B DDG Interface Trail 127
5.5 850B Performance Summary 131
5.6 11M Prototype Design, Manufacturing, Testing and Results 131
5.6.1 11M Prototype Design and FEA 131
5.6.2 11M Prototype Manufacturing 137
5.6.3 11M Prototype Testing – Weight Evaluation Results 139
5.6.4 11M Prototype Testing – Drop Tests 139

Use or disclosure of information contained on this sheet is subject to the restrictions on the cover page of this proposal.

5.6.5 11M Prototype Drop Testing – Instrumentation and Sensor Locations 142
5.6.6 11M Prototype Drop Testing Results 146
5.6.7 11M Prototype Drop Test Data 152
5.6.8 11M Prototype Drop Testing - Conclusions 158
5.6.9 11M Prototype Summary 159
6.0 Benefits Analysis 160
7.0 Implementation Status 160
7.1 Industrial Base 162

Appendices

Appendix A – Test Laminates Mechanical Testing Data

Appendix B – Creep test Data and Results

Appendix C – Resin Workability Manufacturing Trial Test Data and Results

Appendix D – 850A and B Design Requirements Document

Appendix E – 850A Design Presentation and Finite Element Analysis (FEA)

Appendix F – 850B Design Presentation and Finite Element Analysis (FEA)

Appendix G – Craft Performance Evaluations – Test Plan

Appendix H – Hoist Test Reports

Appendix I – 850B Craft Performance Evaluations – Calm Water Test Results Narrative

Appendix J – 850B Craft Performance Evaluations Data Presentation Ocean Runs – Full Load

Appendix K – 850B Craft Performance Evaluations Data Presentation River and Inlet Runs

Appendix L – 850B Craft Performance Evaluations Data Presentation Trailer Testing

Appendix M – 850B Craft Performance Evaluations Data Presentation Air Support Trials

Appendix N – 850B Craft Performance Evaluations Data Presentation Mayport Trial

Appendix O – 11 M Prototype Design Requirements

Appendix P – 11 M Prototype Design Advanced

Use or disclosure of information contained on this sheet is subject to the restrictions on the cover page of this proposal.

Appendix Q – 11 M Prototype Design Fiberglass

Appendix R – 11 M Prototype Drop Test Data

Table of Figures

Figure 1. Navy RIB Being Deployed from Ship (US Navy.) 11
Figure 2. Army Boat Airlifted (US Navy Photo.) 13
Figure 3 - Hull with low section framing. 14
Figure 4 - SharkSkin™ Application. 15
Figure 5 - SharkSkin™ Coating. 16
Figure 6 - Air Support Design Concept. 16
Figure 7 - Laminate under extreme deflection. 17
Figure 8 Laminate water absorption rates 24
Figure 9 Flexural Strength for the hot wet test laminates. 25
Figure 10 Change in flexural strength for the hot wet laminates. 25
Figure 11 Flexural Modulus for hot wet laminates. 26
Figure 12 Change in flexural modulus for the hot wet laminates. 26
Figure 13 Flexural Test (typical) with Coated Face in Tension. 30
Figure 14 Coating Adhesion Test. 30
Figure 15 Biofouling Coupons on Exposure Apparatus. 33
Figure 16 Barnacle Adhesion Test. 34
Figure 17 Barnacle Removal with Scraping Tool. 35
Figure 18 Clean-up with Scotch-Brite Pad. 36
Figure 19 Schematic Loading Diagram. 38
Figure 20 Creep Test Panel Under Load. 39
Figure 21 Infusion Media Trial Set-up. 41
Figure 22 Test Infusion In-progress 42
Figure 23. Hull Framing for the 850A design. 43
Figure 24. Deck Framing for the 850A Design 43
Figure 25. FEA Snapshot - 10 psi pressure load applied to shaded area. 45
Figure 26. REA summary from the load case shown in figure 25. 45
Figure 27 Preform Grid System. 47
Figure 28 Deck Underside Showing Preform Stiffeners. 47
Figure 29 850B Hull Preform Stiffener Beams. 48
Figure 30 850B Deck Preform Stiffener Beams. 49
Figure 31 Hull FEA Example. 51
Figure 32 Hull FEA Result Summary. 52
Figure 33 Hatch Deformation 53
Figure 34 Deck Starboard Cracks 54
Figure 35 Deck Stiffening Modification 55

Use or disclosure of information contained on this sheet is subject to the restrictions on the cover page of this proposal.

Figure 36 Hatch Modification/Rework on the 850B 55
Figure 37 850B Hatch after Infusion being removed from mold 57
Figure 38. 850B hatch after trimming. Part weight 119 lbs. 58
Figure 39 850B deck with vacuum bag in place. 59
Figure 40 Thermal Imaging for vacuum bag leak detection. 59
Figure 41 850B Deck Undergoing Infusion 60
Figure 42 Infused deck of the 850B. 61
Figure 43 850 hull fabrication - leak testing 62
Figure 44 850B hull infusion 62
Figure 45 850B Hull complete with transverse frames installed 63
Figure 46 Locations of Accelerometers, String Pots and Pressure Transducers 64
Figure 47 Location and Orientation of Strain Gauges on the 850B Hull 65
Figure 48 Location of strain gauges on the underside of the deck/hatch of the 850B 66
Figure 49 Unimeasure waterproof strain pot 66
Figure 50 Omega PX140 series differential pressure gauge. 67
Figure 51 850B in single engine configuration - simulated engine failure 70
Figure 52 Fuel vs. Speed Plot for the 850B Calm Water Conditions 71
Figure 53 RPM vs. Speed for the 850B in Calm Water Conditions 71
Figure 54 Miles Per Gallon Fuel usage rate for the 850B in Calm Water Conditions 72
Figure 55 Acceleration data for the 850B in Calm Water Conditions 72
Figure 56 Acceleration data for the 850B in Calm Water Conditions 73
Figure 57 Full Load Ocean Run - Raw Vertical Acceleration Data 75
Figure 58 Raw Vertical Acceleration data for the slam event (PC25 Sept -Ocean-Full Load) 76
Figure 59 Fast Fourier Transform (FFT) of the raw acceleration data (PC25 Sept-Ocean-Full Load) 77
Figure 60 Histogram plot of the unfiltered vertical axis acceleration data (PC25 Sept-Ocean-Full Load) . 78
Figure 61 Zoom view of Histogram Plot of Vertical Acceleration (PC25 Sept-Ocean-Full load) 79
Figure 62 - 20 Hz Butterworth Low Pass Filter of the Vertical Acceleration Data (PC25 Sept - Ocean-Full Load) 80
Figure 63- FFT on the filtered vertical acceleration data (PC25 Sept-Ocean-Full Load) 81
Figure 64 - Hull to Deck deflection Data (PC25 Sept - Ocean-Full Load) 82
Figure 65 - air Pressure in the hull to Deck cavity during the run (PC25-Sept-Ocean-Full Load) 83
Figure 66 - Hull Strain Data during the run (PC 25 Sept-Ocean-Full Load) 84
Figure 67 - Hull Strain Data during the run (PC25 Sept-Ocean-Full Load) 85
Figure 68 - Hull Strain Data during the run (PC 25 Sept-Ocean-Full Load) 86
Figure 69 - Strain Data for the Transom (PC 25 Sept-Ocean-Full Load) 87
Figure 70 - Deck Strain Measurements (PC 25 Sept-Ocean-Full Load) 88
Figure 71 - Strain Data for the Hull Frame Caps (PC25 Sept-Ocean-Full Load) 89
Figure 72 - Strain data for the Hull Panels (PC25 Sept-Ocean-Full Load) 90
Figure 73 - Strain data for the Hull Frame Sidewalls (PC25 Sept-Ocean-Full Load) 91
Figure 74 - Strain Data for the Deck (PC25 Sept-Ocean-Full Load) 92
Figure 75 - Strain Data for the Transom (PC25 Sept-Ocean-Full Load) 93

Use or disclosure of information contained on this sheet is subject to the restrictions on the cover page of this proposal.

Figure 76 - Strain Data for Selected Strain Gauges and the Fwd Outboard String Pot (PC25 Sept-Ocean-Full Load) 94
Figure 77 - Vertical Acceleration Data at LCG and LCG String Pot data (PC25 Sept-Ocean-Full Load) 95
Figure 78 - Deck and Stern Z axis Acceleration data after low pas 20 Hz filtering (PC11-13 Run 3) 96
Figure 79 - String Pot data in inches (PC11-13 Run 3) 97
Figure 80 - Forward section strain data for PC11-13 Run 3 Gauges 1-5 98
Figure 81 - Strain data for PC11-13 Run 3 Gauges 6-9 99
Figure 82 - Strain Data for PC11-13 Run 3 Gauges 10-14 100
Figure 83 - Strain data for PC11-13 Run 3 Transom Gauge 100
Figure 84 - Strain Data for PC11-13 Run 3 Deck Strain Gauges 101
Figure 85 - Helm Z Acceleration and Helm Keel to Deck String Pot data during slam event PC11-8 Run 3 102
Figure 86 - Unfiltered Z axis Acceleration data Inlet Run 7-14-12 103
Figure 87 - Histogram plot of peak Z axis accelerations Inlet Run 7-14-12 104
Figure 88 - Hull to deck deflection data in inches - Inlet Run 7-14-12 105
Figure 89 - Hull Strain data - Inlet Run 7-14-12 106
Figure 90 - Hull strain data - Inlet Run 7-14-12 107
Figure 91 - Hull strain data - Inlet Run 7-14-12 108
Figure 92 - Transom Strain Data - Inlet Run 7-14-12 108
Figure 93 - Deck Strain Data - Inlet Run 7-14-12 109
Figure 94 - Vertical Acceleration (g) Data for the 850B during trailer testing Nov 17 Dirt road in poor condition 20 mph 110
Figure 95 - FFT of the vertical acceleration data - RMS - Nov 11 trailer testing dirt road in poor condition at 20 mph 111
Figure 96 - Histogram plot of unfiltered vertical axis acceleration data. Nov 17 Dirt road in poor condition at 20 mph 112
Figure 97 - String pot data showing combined hull and deck deflection (in.) - Trailer testing Nov 17 Dirt road in poor condition 20 mph 113
Figure 98 - Hull strain data Trailer Run Nov 17 Dirt road poor condition 20 mph 114
Figure 99 - Hull strain data - Trailer Testing Nov 17 Dirt road poor condition 115
Figure 100 - Hull strain data - Trailer Testing Nov 17 Dirt road Poor Condition 115
Figure 101 - Deck Strain Data 116
Figure 102 - Transom Strain Data 116
Figure 103 - Vertical Acceleration data (g) during hull pressurization test on trailer 117
Figure 104 - FFT of the vertical acceleration data during hull pressure test on the trailer 118
Figure 105 - String pot data showing hull to deck deflection during pressure testing while on the trailer 119
Figure 106 - Hull pressure (psi) during pressure testing while on the trailer 120
Figure 107 - Deck strain data during the pressure test while on the trailer 121
Figure 108 - Vertical Acceleration data (g) during hull pressurization wake jumping 19 Aug 12 122
Figure 109 - FFT of vertical acceleration data for pressure test run wake jumping 19 Aug 12 123

Use or disclosure of information contained on this sheet is subject to the restrictions on the cover page of this proposal.

Figure 110 - Histogram plot of peak accelerations, hull pressure test, wake jumping 19 Aug 12 124
Figure 111 - String Pot data showing hull to deck deflection during pressure tests, wake jumping 19 Aug 12 125
Figure 112 - Hull to deck pressure (psi) during pressure testing, wake jumping 19 Aug 12 126
Figure 113 - 850B hoisting onto USS Roosevelt (DDG-80) 127
Figure 114 - 850B Lowering on ship's cradle 128
Figure 115 - Ladder interferes with fit. Deflating the collar allows craft to fit 128
Figure 116 - 850B on Cradle with Collar Deflated 129
Figure 117 - 850B in Dock Area, Mayport Trial Run 130
Figure 118 - Hull Drawing for the 11 M Fiber glass Design 132
Figure 119 - Deck Drawing for the 11M Fiber Glass Design 133
Figure 120 - Deck Detail Drawing for the 11M Fiber Glass Design 134
Figure 121 - Load cases evaluated for the 11M Fiber Glass Design 135
Figure 122 - Small Area Slam FEA GRid for the 11M Fiber Glass Design 136
Figure 123 - Results from the above FEA for the 11M Fiber Glass Design 136
Figure 124 - Weight Projections for both the Advanced and Fiber Glass designs 137
Figure 125 - 11M prototype with preforms installed 137
Figure 126 - 11M prototype infusion preparation 138
Figure 127 - 11M prototype infusion preparation 138
Figure 128 - Zodiac drawing showing standard configuration 140
Figure 129 - Weight plan for the 11M drop testing 141
Figure 130 - Hull cavity ballast for 11M prototype drop test 142
Figure 131 - Accelerometer and string pot locations on the 11M prototype hull 142
Figure 132 - Hull Strain Gauge locations for the 11M prototype 143
Figure 133 - Location of deck accelerometers and string pots for the 11M prototype 143
Figure 134 - Accelerometer, String Pot and Hatch strain gauge locations for the 11M prototype 144
Figure 135 - Deck Strain Gauge locations for the 11M prototype 144
Figure 136 - Forward Accelerometer placement 11M 145
Figure 137 - Aft Accelerometer placement 11M 145
Figure 138 - 11M prototype prior to adding deck ballast 146
Figure 139 - 11M prototyoe undergoing drop testing 147
Figure 140 - Drop test 11M Prototype 148
Figure 141 - Flange damage near the engine compartment 149
Figure 142 - Port Aft Engine Compartment Showing Damage 150
Figure 143 - Deck Flange showing damage due to fastener (temporary screw holding deck) 150
Figure 144 - Deck Drain to engine compartment showing some separation 151
Figure 145 - Damage to deck flange where an aluminum cross member sits 151
Figure 146 - Damage to mid Deck cross beam where it meets longitudinal 152
Figure 147 - Unfiltered Vertical Axis Acceleration data (g), Drop 1, 11M Prototype 153
Figure 148 - Vertical Acceleration Data (g) Slam event, 11M Drop 1 154
Figure 149 - FFT of Vertical Acceleration Data, Drop 1, 11M 155

Use or disclosure of information contained on this sheet is subject to the restrictions on the cover page of this proposal.

Figure 150 - String Pot Data, Drop 1, 11M 155
Figure 151 - Data from Strain Gauges 1-8, Drop 1, 11M 156
Figure 152 - Strain Data Gauges 9-16, Drop 1, 11M 157
Figure 153 - Strain Data Gauges 17-24, Drop 1, 11M 158

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1.0 Introduction/Summary

High-speed small craft platforms are improving mission capabilities and helping to reduce risk for U.S. and allied blue and brown water Navies in numerous low intensity conflicts around the world. The demands on combatant craft are ever increasing. Increased payloads, longer duration, increased crew requirements, and missions that subject crew to ballistic threats are increasing the cost and weight of the craft.

Increasing requirements of combatant craft create challenges for the platform. The principal challenge is to reduce the structural weight of the vessel. Reduction of weight allows for extended missions, improved performance and/or increased mission packages. Weight reduction is also very important to the time and effort required in mobilization, as nearly all small craft need to be transported, handled, launched and recovered - often in environments aboard other Naval assets with reduced crew count, such as surface ships, figure 1. Increased weight currently causes numerous complications in all four areas.



Figure 1. Navy RIB Being Deployed from Ship (US Navy.)

Transportation of the boat to the mission area is primarily achieved by using a larger surface craft or an aircraft. In either case the increased weight has a negative impact on the host platform. Heavier weights require stronger and heavier cradles and support equipment. Increased vessel weights also negatively impact safe operations during launch and recovery. The increased weight and inertia requires stronger and heavier deck handling equipment, and usually equates to

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additional handling crew requirements. Reducing structural weight while retaining adequate strength can benefit all areas of craft performance and mission capability.

This effort leverages and advances the TRL from work completed by Structural Composites Inc. (SCI) in Phase I and Phase II SBIR N091-049 Advanced Combatant Craft for Increased Affordability. In the SBIR, SCI focused on the 7 meter craft size to develop and advance the basic technology. This effort focused on two larger 8.5 meter and 11 meter RIB platforms that have strong insertion potential in addition to supporting efforts to upgrade the industrial base.

This program represents a paradigm shift from the current conventional small craft construction approach of rigid sandwich and solid FRP construction to a lightweight membrane tension construction. The design utilizes new advanced materials that reduce weight and improve toughness. The net benefits are a design and manufacturing process that reduces craft weight, mitigates shock loads, reduces maintenance cost, improves survivability, and maintains or extends the longevity of the platform. Due to the elimination of a significant amount of materials, acquisition cost when deployed is projected to be maintained or reduced for many applications.

The project has advanced and demonstrated technology that significantly reduced weight and improved craft ride conditions. This provides benefits for:

- Warfighter: Boats with improved shock mitigation that reduce injuries from severe shock caused by wave impacts
- Program Office: Lighter weight boats to support increasing mission profiles
- Logistics Organizations: Reduce the payload impact on transport aircraft, transport vessels and shipboard deployment and retrieval systems making it easier to transport, deploy and retrieve the boats

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Figure 2. Army Boat Airlifted (US Navy Photo.)

Other military programs are expected to be able to leverage the technology benefits developed under this project. Platforms such as the LCS, DDG51 and the Coast Guard Deep Water project will benefit from the low cost single skin construction method and increased ruggedness developed and validated for combatant craft.

Other branches of the military use small boats extensively. Many of these applications place the vessel in situations that can result in groundings and damage to the craft. Increasing the toughness of these smaller platforms will help improve the survivability of the craft, reduce maintenance costs, and extend the longevity of the platforms.

The project advanced several individual portable technologies that have application to a wide range of government and commercial applications. Applications such as shelters, housing, ground vehicles, trailers, ships and hovercraft can benefit from low cost lightweight structures.

2.0 Background/Problem Statement

The industrial base that supplies government boats is in need of improved manufacturing methods and materials. Government boats include small watercraft used by the Navy, Army, Coast Guard, Marine Patrol, Police, Homeland Defense and even the Air Force. Current manufacturing processes and materials will not meet the Navy's need for lightweight, better performing boats. This applies equally to the entire boatbuilding industrial base as well, since much of the materials and processes are substantially identical.

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The current technology for government boats is a direct extension from the recreational boat industry. These boats rely on designs based on materials and manufacturing technology that result in heavy rigid structures. While durable, the excess weight limits mission capabilities and the rigid construction transfers shock loads due to wave impact to operators and crew.

3.0 Objectives

The objective of this program was to develop manufacturing technology systems that combine new advanced materials and composite manufacturing technology to produce lightweight, robust and affordable rigid inflatable boats. This program developed three RIB boat designs:

- 8.5m (alpha) low risk, modest weight design improvement for a Navy dive support requirement
- 8.5m (bravo) moderate risk and weight design to be a concept candidate for next generation RIB
- 11m moderate risk and weight design to be a concept candidate for Zodiac's new high speed (60 knot) interceptor RIB or next generation 11M RIB (at lower speeds).

From the developed designs, the project fabricated and tested the 8.5m and 11m moderate risk RIBs.

The new composite designs represent a paradigm shift from the current conventional construction approach of rigid sandwich construction to a new lightweight framed single skin hull and deck construction. The design utilizes advanced materials to reduce weight and improve toughness. The net benefits are a hull design and manufacturing process that reduces craft weight, mitigates shock loads, reduces maintenance cost, improves survivability, and extends the longevity of the platform.

4.0 Approach

Previous design work blends approaches from aerospace and recreational marine industries and adds a healthy batch of innovation. The result lays the foundation to deploy an affordable, durable, lightweight structural design and manufacturing process that can be applied to a broad class of high-speed small craft.

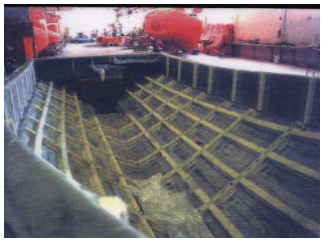


Figure 3 - Hull with low section framing.

Significant weight savings are achieved by combining structural optimization with functional integration. Following the hybrid structural taxonomy of airframes, the combined vector/section activity provides major opportunity for ultra light structures. The structure is now an advanced single skin fabrication. The boat hull has lightweight thin skins that have extensive low section – high strain rate-framing, as illustrated in figure 3.

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By moving to the air frame structural approach marine structures can now be designed that will be lightweight and allow impact energies to be dissipated though inherent structural damping. This diverges from the conventional boat building approach of making inflexible longitudinal, stringers and bulkheads supporting outer skins which results in a very stiff, heavy structure and has increased shock loads to crew and equipment.

Two key aspects of conventional boat building need to evolve in order to develop a more flexible structure. First is the modification of the rigid outer finish, currently a rigid gel coat. Gel coat is a specially formulated polyester resin system that protects the laminate from water infiltration and UV radiation. Gel coat is a structural weak link in the composite system. It's very low strain-to-failure and its location on the outer surface combine to make this the first material to fail. Gel coat cracking is problematic as over time cracks can propagate into the structural layers of the craft. To put this in perspective, more than half of all recreational boat warrantee claims involve gel coat related failures.

Recreational boat builders have learned that the solution to reducing gel coat cracking is to reduce the strain on the gel coat. The strain is reduced by making the laminate thicker and thus heavier. One key element to reducing weight is to modify the outer coating to allow for larger strains, but still protect the laminate from the elements.

An emerging Structural Composites, Inc. (SC) technology trademarked "SharkSkin™" is a cost effective alternative to gel coat for use in marine structures. The material is a tough elastomeric polyurethane or polyurea similar to that used in truck bed liners, dredge pipes and even Navy Composite Rudders. The SharkSkin™ protects the laminate from the environment, helps prevent the internal laminate from cracking and acts as a damping layer. Replacing the low elongation gel coat with a high elongation elastomer is the first step in reducing weight, as the structure can now make full use of the underlying laminate properties.

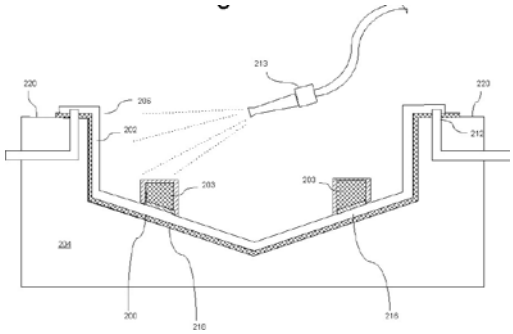


Figure 4 - SharkSkin™ Application.

The SharkSkin™ approach can be used on both the outside and inside of the hull as illustrated in figure 4. SharkSkin™ Infusion is an environmentally friendly alternative to open molding. It is an innovative, patented, closed molding approach that produces a high quality laminate with an integral urethane coating (Johnson, Lewit US Patent # 6723273). Conventional resin infusion uses a vacuum bag with large quantities of expendables that require disposal. In SharkSkin™ infusion, the vacuum barrier is formed when the elastomer is sprayed directly on the dry laminate fibers, thus forming an in place 'vacuum bag', figure 5. Once the vacuum integrity of the sprayed skin is verified; resin is injected into the part and allowed to cure. The result is a closed molded high quality laminate that has the urethane coating intimately connected to the laminate.

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The second aspect to reducing weight is a revised structural framing configuration. Conventional small boat construction relies on high section framing to stiffen the structure. This often leads to large stiffeners and sandwich construction bridges between frames. This approach produces a very rigid structure, with increased weight and increased shock loads.



Figure 5 - SharkSkin™ Coating.

The low section framing evenly distributes stress, provides sufficient stiffness, reduces weight and allows larger deflection during severe loading events such as wave slamming or grounding. Absorbing the energy through structural deflection reduces the shock loads that the payload and crew experience.

Combining the low section single skin approach with the SharkSkin™ technology achieves an affordable lightweight structure that has exceptional toughness and durability. The vessel now acts as a classic shock absorbing strut component of a structural "suspension" system where the low section framing and thin skin laminate act as the spring component and the elastomeric coating provides inherent damping control.

To further reduce weight, low density, high elongation fiber materials and an innovative design concept that uses air pressure to support the structure were investigated, figure 6. The innovation harnesses the effect of entrapped air for use in supporting a much lighter structure while simultaneously reducing shock.

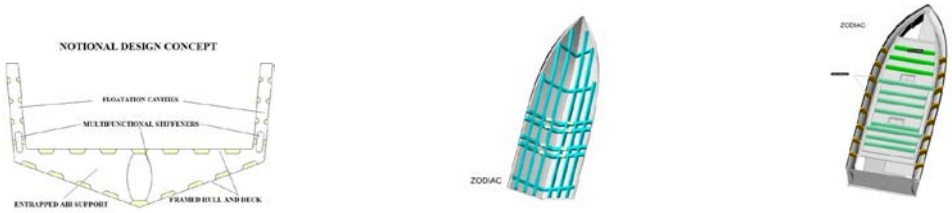


Figure 6 - Air Support Design Concept.

The air support system is multifunctional. It provides support for the hull and deck structure and acts as a shock mitigation system that will reduce impact shock and help stabilize the craft. The air system uses a high volume low pressure fan to deliver low level air pressure. Like the fans used to lift hovercraft, these fans are ideally suited, as air can back flow through the fan during a shock event. Supporting the thin skin framed laminate with air pressure provides the functionality of a solid hull with the lightweight advantages of an inflatable. The structure was designed to be rigid enough to operate with a complete loss of the active inflation system.

The hull to deck connection will have special accommodation for the lightweight design. The conventional method of connecting the hull to the deck with large stringers and bulkheads would

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be counter to the hybrid skin/framed approach. Prisma™ performs were used as shear ties and shock absorbers for the special hull to deck connection.

New low density, higher strain rate fiber systems identified during the Phase I SBIR were evaluated to complement the hybrid skin/frame membrane concept. The new high modulus polypropylene fiber Innegra S is a breakthrough low cost, low density structural fiber. The fiber has a specific gravity of 0.67 g/cc compared to conventional glass fibers at 2.5 g/cc.



Figure 7 - Laminate under extreme deflection.

The fiber imparts enhanced toughness to a laminate due to its high strain-to-failure rate. The single skin framed construction approach helps capitalize on the toughness. Notice the ability of the laminate to undergo extreme deflection even under short support spans, figure 7.

The proposed construction is quite different from conventional sandwich structures. The hybrid combination of thin skins and low section framing allow the laminate to transition from conventional bending to a loading condition called membrane tension. In conventional bending, one side of the laminate is in tension and the other in compression, working against each other to produce a flexural stiff structure.

The Phase I SBIR effort produced three lightweight design concepts. The three designs use the Prisma™ Single Skin Technology (SST), the SharkSkin™ Coating and the suspended cockpit concept. Two of the designs were advanced designs that are intended to be evaluated with and without the air support system. All approaches rely on innovative process enhancements to substantiate existing factory tooling and standard practices.

This program advanced the SBIR design concepts for application to the 8.5m and 11m RHIBs. With concurrence from the Navy, two designs were selected for construction and evaluation.

4.1 Statement of Work

The work plan established a series of tasks that resulted in an innovative lightweight structure for use on combatant craft structures. An 11 meter and an 8.5 meter RHIB were selected based on previous knowledge and experience with these platforms, however the structural approach and manufacturing innovation can apply to other combat craft, potentially up to100 ft in length.

Task 1 Detailed Design, Design Optimization and Risk Reduction

Task 1 consisted of developing and refining three preliminary designs for:

- 8.5m (alpha) low risk, modest weight design improvement for a Navy dive support requirement
- 8.5m (bravo) moderate risk and weight design to be a concept candidate for next generation RIB

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- 11m moderate risk and weight design to be a concept candidate for Zodiac's new high speed (60 knot) interceptor RIB or next generation 11M RIB (at lower speeds).

Two of the designs, the 8.5m B and 11m were down-selected and detailed plans were developed for construction. This task optimized each of the design concepts and performed a risk analysis and reduction program. Each of the three detailed designs was further validated through mechanical and physical testing. High risk areas were identified and risk assessed. A risk reduction program addressed technical areas of concern.

Key design areas that were to be addressed include but are not limited to:

- Optimization of SharkSkin^{TM} Coating
- Laminate Creep Assessments under High Temperature and High Load Conditions
- Hull Slamming / Air Support Assessment
- Cradle/ Trailer / Transport Structural Assessment
- Hoisting and Handling Assessment
- Engine Drive Train alignment
- Console Weight Reduction Evaluation

Completion of the detailed design, optimization and risk reduction preceded the final design for the 11 M and 8.5 M RHIB. Design documentation, manufacturing op sheets and tooling descriptions were detailed enough so that the three vessels could be fabricated, and the concepts applied to other vessels in the future by suppliers 'practiced in the art' of composite boat building.

Task 2 Manufacturing Development & Vessel Construction

Task 2 developed the manufacturing technology to produce two candidate vessels, one boat was constructed by Brunswick Commercial Products (8.5m RIB) the other by Zodiac Hurricane Technologies (11m RIB).

This project provided sufficient funds for an operational 8.5 M RHIB. For the 11 M RHIB to be operational, a government furnished equipment (GFE) propulsion system was proposed, with a contingency if a GFE propulsion was not available. A GFE propulsion was not available, so representative weights were installed in the craft to represent the change and the boat underwent water drop testing to evaluate the structure.

The project goal was to develop the manufacturing technology to provide the Navy with two functional vessels that can be placed into the field for longer-term validation and evaluations. Two lightweight hulls and decks were produced. One 8.5M functional craft was delivered to the Navy. Absent of the GFE propulsion, the 11M craft is currently at Zodiac awaiting further funding to complete the build out and evaluations.

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Task 3 Cost and Performance Evaluation & Validation

Task 3 completes the design spiral with testing of actual craft performance and structural response, and comparison of results to calculations performed in the design. Task 3 focused on evaluation and reporting of cost and performance of each of the two test craft. Craft performance data includes operational performance, structural performance and operator/crew benefit. To accomplish this, the two platforms were instrumented with strain gauges and accelerometers to measure the structural response in various operating conditions.

A test plan for the fully functional prototype boat was developed in collaboration with the Navy. The scope of the testing included:

-Trailer and Transport Testing
-Launch & Recovery Evaluation
-Operational Testing
    -Vessel Structural
    -Vessel Performance
    -Design Impact on Crew Ride

To further advance the technology, the fully functional 8.5 M vessel has been transferred to the Navy for long term durability and performance assessments.

Task 4 Program Management

Task 4 provided for the effective management of this program, including preparing and submitting the required program and technical deliverables. This task extended from contract award to completion.

Team Organization: The project team included SCRA Applied R&D as Project Manager to ensure the project remains on schedule, on budget and on task and also to provide oversight to ensure that necessary steps are followed to ensure transition. Structural Composites, Inc. (Small Business) served as the Technical Lead and oversaw the technical tasks. Lockheed Martin served as a design consultant. Brunswick Commercial Products and Zodiac Hurricane Technologies are component suppliers and constructed the vessels described in Task 2.

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5.0 Results and Discussion

5.1 Preliminary Testing

5.1.1 Mechanical Properties Tests

Test panels were fabricated in order to establish baseline mechanical properties for a low risk (850A) and moderate (850B) laminate schedules. The reinforcement was of 36 oz/yd^2 0°/90° E-glass construction, with a ply of 1 oz/ft^2 chopped strand mat stitched to it. The product was obtained from Vectorply, and the product code was E-LTM 3610.

Three plies of 3610 were laid up using conventional hand layup techniques, to represent the 850A base laminate. The same laminate schedule was used to represent the 850B, but the panel was fabricated using the resin infusion process, instead of hand layup. The resin infusion process uses atmospheric pressure to consolidate the laminate under a vacuum bag. The resin is drawn into the laminate using vacuum ports.

Both laminates were fabricated with the same resin, an Alpha-Owens-Corning (AOC) K022 fire-retardant product currently used for the 850 RIB program at Brunswick Commercial and Government Products (BCGP), Edgewater, FL.

The resulting test panels were allowed to cure under ambient Florida environmental conditions for a minimum of 2 weeks prior to test. Test coupons were then cut from the panels, and the mechanical properties were determined using ASTM methods commonly used for composite laminates.

Representative test data (tensile, compressive, flexure) are shown below for each laminate in Tables 1 and 2. Full test data are included in Appendix A.

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Panel Identification: 850A Hull

Hand Layup
AOC K022-CCK-18
Vectorply E-LTM 3610 (3 plies, 0/90/0/90/0/90)

Table 1. Mechanical and Physical Properties, 850A Laminate.
(Note: All values represent ambient lab conditions unless otherwise noted.)

Property	**Value**
ASTM D3039 Tensile Strength, 0°	38.9 ksi
ASTM D3039 Tensile Modulus, 0°	2.01 msi
ASTM D6641 Compressive Strength, 0°	41.2 ksi
ASTM D6641 Compressive Modulus, 0°	2.39 msi
ASTM D790 Flexural Strength, 0°	59.1 ksi
ASTM D790 Flexural Modulus, 0°	1.46 msi
ASTM D2584 Resin Content	51.0 % by weight
ASTM D2584 Glass Content	49.0 % by weight
Laminated Thickness Per Ply	0.080 in.

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Panel Identification:

850B Hull
Resin Infusion
AOC K022-EBB-00
Vectorply E-LTM 3610 (3 plies, 0/90/0/90/0/90)

Table 2. Mechanical and Physical Properties, 850B Laminate.
(Note: All values represent ambient lab conditions unless otherwise noted.)

Property	Value
ASTM D3039 Tensile Strength, 0°	44.7 ksi
ASTM D3039 Tensile Modulus, 0°	2.41 msi
ASTM D6641 Compressive Strength, 0°	47.0 ksi
ASTM D6641 Compressive Modulus, 0°	3.66 msi
ASTM D790 Flexural Strength, 0°	84.6 ksi
ASTM D790 Flexural Modulus, 0°	2.57 msi
ASTM D2584 Resin Content	34.4 % by weight
ASTM D2584 Glass Content	65.6 % by weight
Laminated Thickness Per Ply	0.049 in.

Both the hand lamination and infusion grades of AOC K022 resins had good mechanical properties. As expected, the infused laminate had higher mechanical properties; this is attributed to the higher fiber content. These results indicate that the AOC K022 infusion laminate has the workability and mechanical properties that are acceptable for the 850B craft.

5.1.2 Water Absorption Testing

Water absorption trials were conducted on laminate test coupons made with Vectorply's Innegra reinforcement material. A test panel was fabricated using Interplastic CORVE 8106 resin and Vectorply I-BX 1200. The laminate contained 3 plies of reinforcement.

After cure, test coupons were cut from the panel for a water absorption test. The test coupon size was approximately 1" x 3". The cut edges were not sealed. The coupons were immersed in room-temperature distilled water for 72 hours. The results are shown in table 3.

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Table 3. Innegra Test Coupon Water Absorption Results.

Length of Immersion (hours)	Water Absorption (% by weight)
24	4.0
48	3.7
72	4.1

Each value represents the average of 3 test coupons. The average test results all fell within a standard deviation of each other. It appears that the short-term water absorption of this type of laminate is around 4%.

5.1.3 Additional Water Absorption Testing

The water absorption test results created a concern about the Innegra fiber. The results show a rather large percentage uptake of water. One factor is that the Innegra laminate is lower in density than the typical fiberglass laminate. However, even factoring the lower laminate density, the water absorptions were higher when compared to fiberglass laminates.

The Navy has experience and issues with Kevlar and water absorption. Studies have shown that Kevlar laminates have reduced material properties associated with water absorption. As Innegra is a new material in marine composites applications, little or no data was available on the effect of water absorption on the properties of Innegra laminates. To better understand if this fiber has an issue similar to Kevlar, a water absorption test was conducted and laminates were tested. Laminates were conditioned for two weeks in seawater at 65^{o}C and tested. Five laminates were evaluated. These were:

1) Innegra Laminate VE resin
2) Innegra/Carbon Laminate Epoxy Resin
3) Innegra/ Carbon Laminate VE Resin
4) Carbon Laminate VE Resin
5) E-glass Laminate VE Resin

Laminates 2 and 3 were the candidate laminates for the advanced design options, laminate 5 is the laminate for the fiberglass design and laminates 1 and 4 were included to provide data without multiple fiber types. Figure 8 below shows the water absorption rates from the tests.

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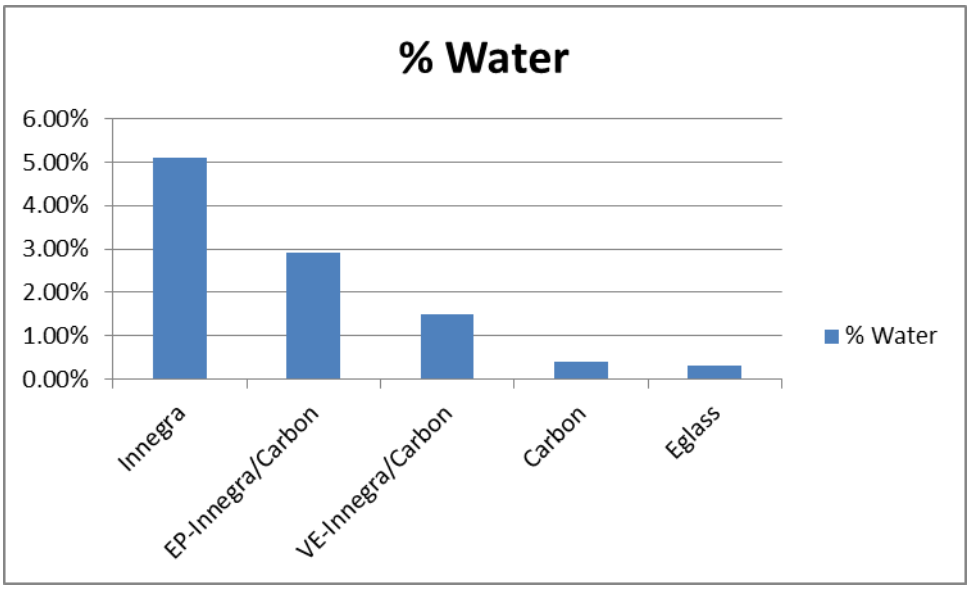


Figure 8 Laminate water absorption rates

As seen in figure 8, water absorption rates are higher for the Innegra based laminates. The relatively high water intake is not necessarily an issue; the concern is the effect the water intake has on mechanical properties. To assess the effect, the flexural properties (strength and modulus) were determined for the hot-wet laminates and compared to the unexposed laminates (dry). The test matrix included candidate hull laminates which were Innegra/Carbon in both Epoxy resin and Vinyl ester resin, along with the low risk E-Glass laminate. A carbon laminate and an Innegra laminate were added to the test matrix so that the properties of the hybrid laminates could be discerned from the properties of non-hybrid laminates. Figures 9-12 show the flexural properties followed by a discussion of the results.

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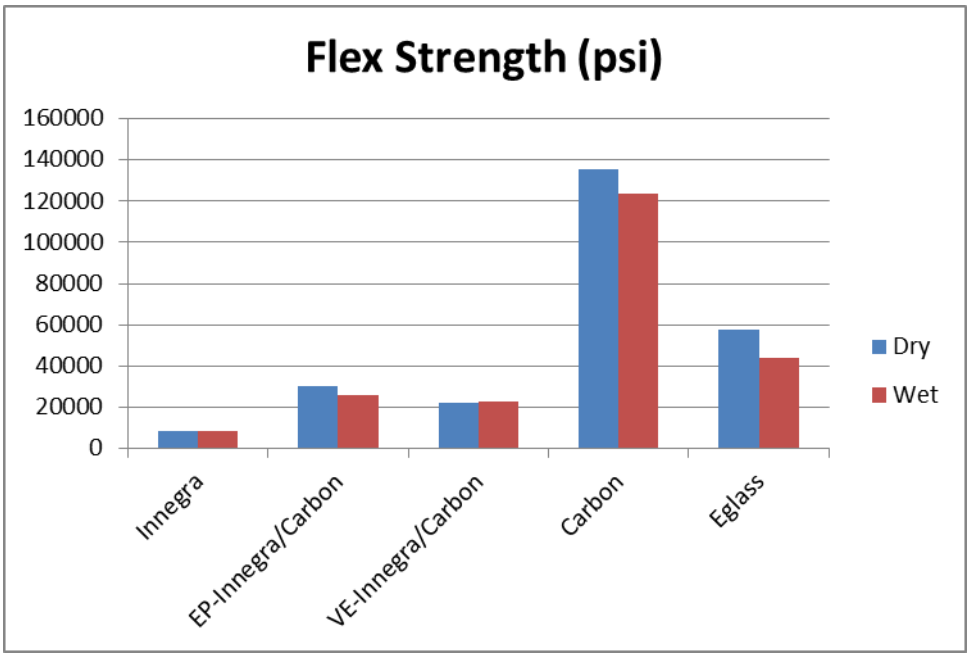


Figure 9 Flexural Strength for the hot wet test laminates.

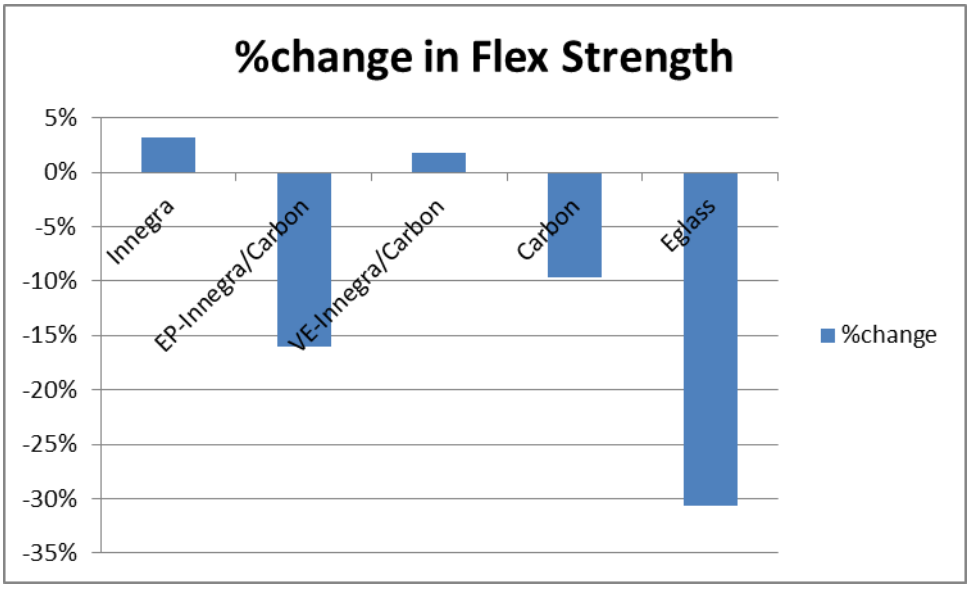


Figure 10 Change in flexural strength for the hot wet laminates.

As the above figures 9 & 10 show, the flexural strength test data indicates that Innegra laminates did not lose flexural strength. The epoxy based Innegra carbon laminate did show a loss of flexural strength, while the VE resin based Innegra carbon laminate did not show a loss.

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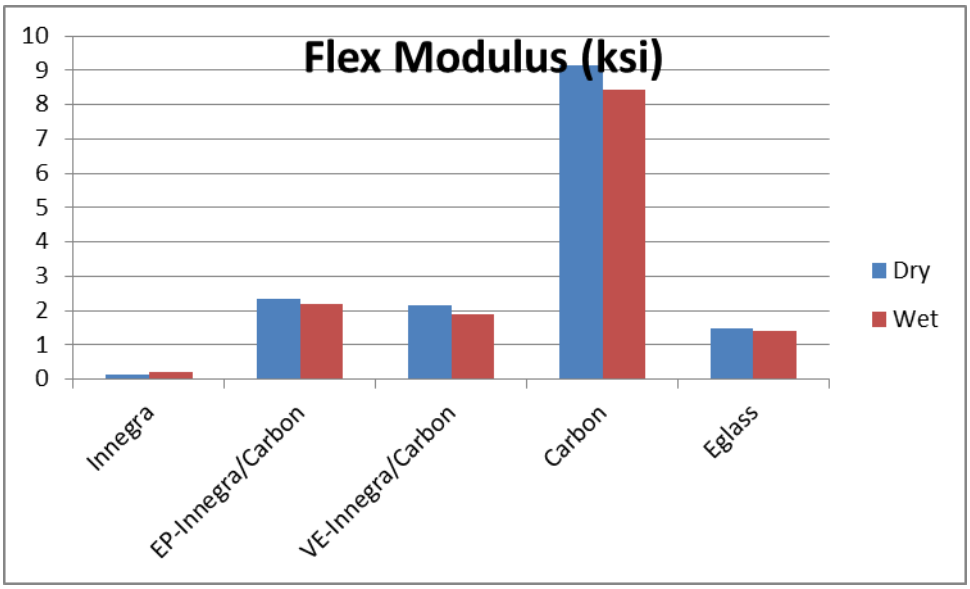


Figure 11 Flexural Modulus for hot wet laminates.

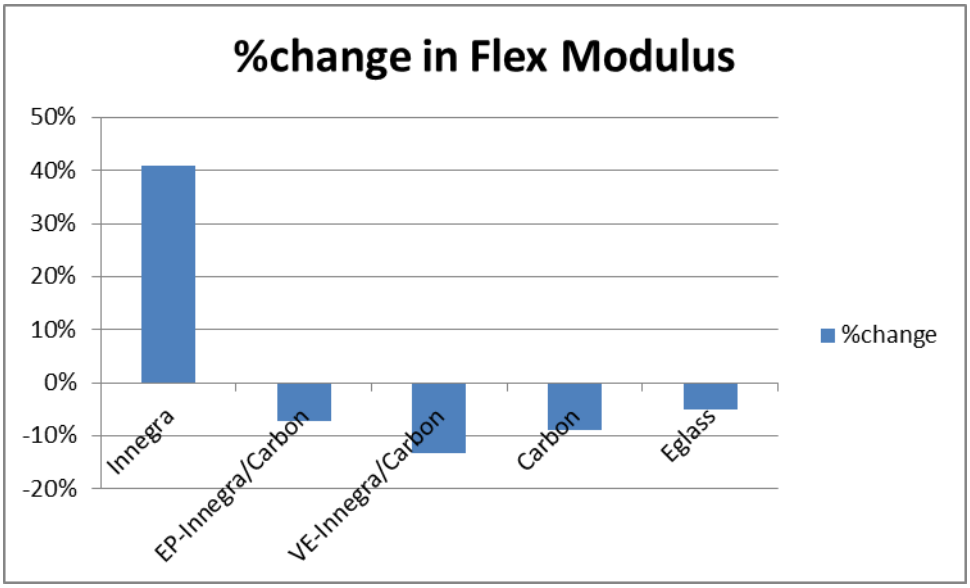


Figure 12 Change in flexural modulus for the hot wet laminates.

Flexural modulus data, figures 11 & 12, indicate that the Innegra laminates' flexural modulus was not adversely affected by water. The remainder of the laminates all had similar flexural modulus reductions.

The tests indicate that the Innegra does absorb more water than fiberglass or carbon based laminates. It appears that this absorption does not adversely affect the flexural properties of the Innegra. Note that the Innegra properties are low when compared to fiberglass or carbon based laminates. The Innegra in this particular application is not used to provide strength but to help

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toughen and protect the carbon laminate. Additional testing is recommended to further understand the behavior of this fiber for marine applications.

5.1.4 Coatings Evaluations – Mechanical Properties

The use of experimental urethane hybrid coatings in marine structures is a recent development. The coatings have the potential to provide protection to the laminate, improve laminate damping and improve impact and abrasion toughness. Several coatings were evaluated for potential use in key areas of the boat. The 850B boat is a low risk and low cost boat, as such it was proposed to use the experimental urethane coating on a hatch surface of that boat. The other potential applications were investigated for possible implementation on an 11 M RHIB advanced laminate boat, which was not fabricated under this program.

Candidate coatings were investigated as both an in-mold coating and as a post-applied coating. Table 4 shows the coatings that were evaluated.

Table 4. Coatings Matrix

Coating ID	Description	Notes
C1	Commercial Coating	Line-X- Type formulation (used in Phase I SBIR)
SharkSkin™	Polyurethane	Experimental Polyurethane Hybrid
G4	Gel Coat	Commercial gel coat as Baseline

One key aspect of the coating evaluation was to measure the coating adhesion to the laminate. Good adhesion is critical for the coating when being used as a gel coat replacement on the hull running surface, as peel due to hydraulic pressure is a major concern. The other property which was measured was coating strain-to-crack, using a simply-supported 3-point bending apparatus.

5.1.4.1 Test Panel Fabrication

In discussions with the coating supplier, it was apparent that better bonding would be achieved between the coating and the laminate if resin is applied to the uncured coating. There are two practical methods. One is to spray VE resin on the uncured coating; the second is to apply a skin coat onto the uncured coating. A third method, one used previously, is to create a mechanical tie coat using a tough thermoplastic polyester mat. Here the polyester mat is applied to the urethane coating so that it is only partially saturated with the coating, leaving dry fibers that will infuse with the base laminate.

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In-mold application of the coating has several process and cost advantages. Several methods for in-mold application were evaluated to see which method gave the best bond to the laminate. Tables 5 & 6 below show the production methods that were investigated and the coated panel list.

Table 5. Coating Application Methods.

Method ID	Description	Notes
-RS	VE resin sprayed onto curing Coating	Create Chemical Bond
-SK	VE resin and skin coat onto curing coating	Create Chemical Bond w/fibers
-TD	Trevira –Tie Coat- dry mechanical	Trevira bedded in uncured urethane and with dry fibers on surface
-PA	Post-Applied Coating	Paint, Line-X

Table 6. Coating Panel Matrix.

Panel-ID (Screening Test- One panel of each to be fabricated)	Construction
C1-PA	Post Applied Commercial Coating
SharkSkin™-RS	In Mold- Resin Spray
SharkSkin™-SK	In Mold- Skin Coat
SharkSkin™-TD	In Mold- Tie Coat
G4	In Mold- Conventional Gel Coat

C1 is a commercial off the shelf formulation that was used in the Phase I SBIR test program. This coating is best suited to post application as it has a fast cure time. The SharkSkin™ coating is a high grade extended cure time formulation that offers the potential to be applied in-mold or post applied. G4 is the conventional gel coat currently being used on the 850.

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5.1.4.2 Testing

Note: The original test plan included several peel tests. This type of test works on elastic, rubbery-type coatings. The coating is "peeled" from the base laminate. It was quickly apparent that all of the candidate coatings were of lower elongation (less elastic) than anticipated. Also, the adhesion to the fiberglass laminate substrate was higher than expected (> 500 psi, in all cases). For these reasons, the peel tests were dropped from the program. Strain-to-failure tests (in flexure) were added, to determine resistance to coating cracks.

Structural laminates were constructed by hand layup techniques, according to the laminate schedule for the 850B RHIB design. Laminates were trimmed and post cured prior to testing. The cured coated laminates were subjected to the following tests, table 7:

Table 7. Coating Panel Test Matrix.

ASTM Number (Screening test) 1 set of 3-5 test specimens	**Description**
D790	Flexural Test- Observe Coating
D4541	Coating Adhesion test

Flexural and adhesion tests were performed on the coated laminates, figures 13 & 14. Flexural tests were performed using a standard method for composite panels (ASTM D790). The test specimens were loaded with the coated face in tension, using a simply-supported 3-point bend test apparatus, figure 13. The results are presented and discussed in the next section following the figures.

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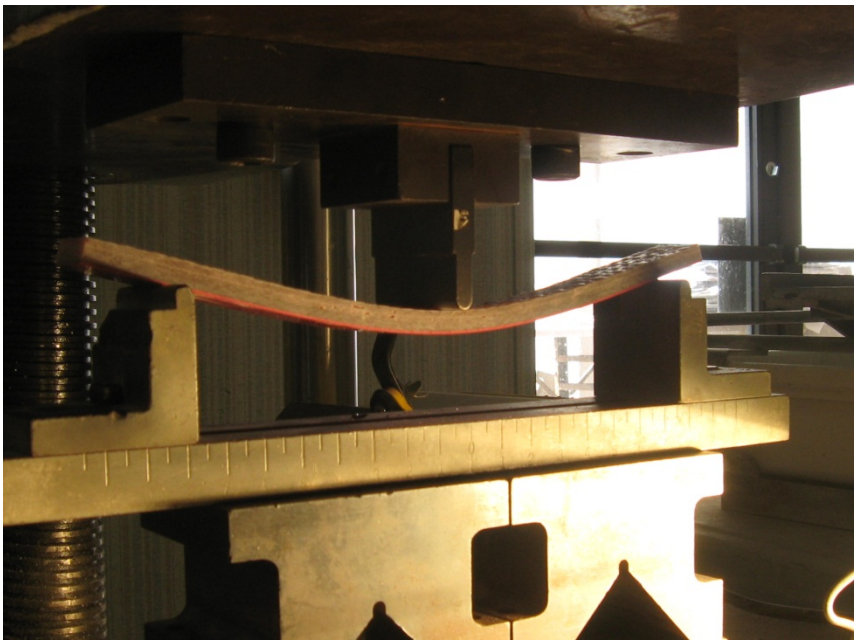


Figure 13 Flexural Test (typical) with Coated Face in Tension.

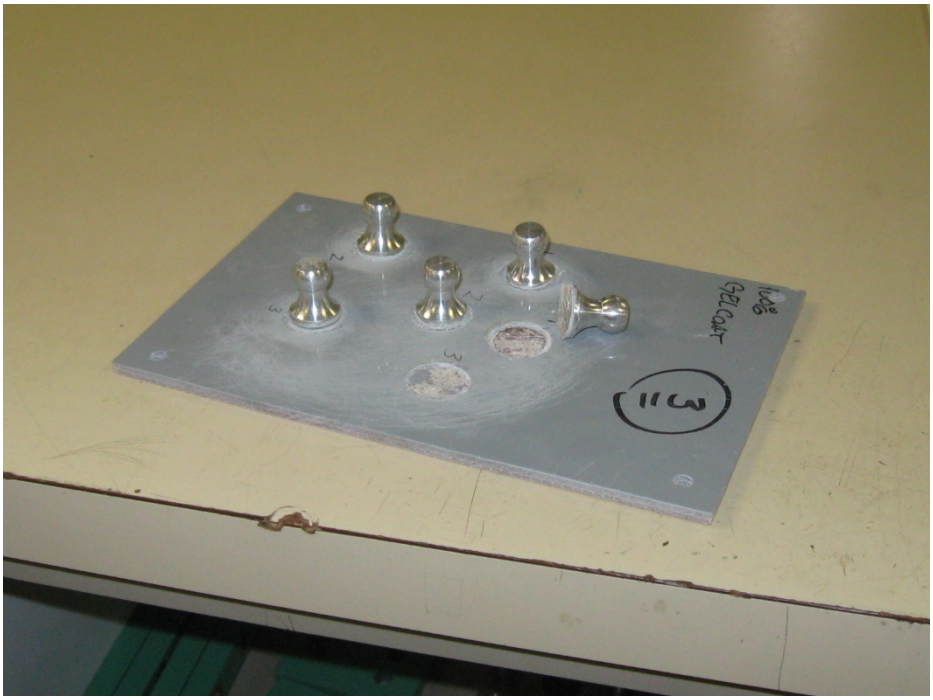


Figure 14 Coating Adhesion Test.

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5.1.4.3 Mechanical Test Results

The mechanical test results are shown in table 8.

Table 8. Coating Panel Mechanical Test Results.

Panel-ID	**ASTM D4541** **Coating Adhesion Strength (psi)**	**ASTM D790** **Strain at Coating Crack (%)**
C1-PA	864	Not tested
SharkSkin™-RS	1736	6
SharkSkin™-SK	1899	7
SharkSkin™-TD	2214	7
G4	1011	2

The results indicate that the SharkSkin™- coatings out-perform conventional gel coat in terms of adhesion to the laminate and strain at coating cracking. The in-mold SharkSkin™ coatings also outperformed laminates that were post-coated with a commercial polyurea material in terms of coating adhesion strength. The increase in strain at cracking to six percent or higher for the SharkSkin™ coatings results in the coating having higher strain to failure than the E-glass base laminate.

5.1.5 Coatings Evaluations – Biofouling

Note: A portion of this work was completed under funding for another program –
Contract No. N00024-11-C-4100
SBIR Phase II Topic N091-049
Advanced Combatant Craft for Increased Affordability & Mission Performance

Several hull coatings were evaluated for adhesion to a fiberglass hull substrate, and resistance to biofouling. These coatings (some experimental) were all intended for use on fiberglass reinforced plastic (FRP) hulls.

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5.1.5.1 Test Panel Fabrication

Test panels were fabricated using a marine-grade vinyl ester resin (Interplastic VE8123), and a knitted 0°/90° biaxial E-glass reinforcement. The reinforcement was of 36 oz/yd^2 0°/90° E-glass construction, with a ply of 1 oz/ft^2 chopped strand mat stitched to it. The product was obtained from Vectorply, and the product code was E-LTM 3610.

Some coatings were applied in-mold, while others were post-applied to the cured laminate mold face. In the cases where the coating was applied after laminate cure, the surface was scuffed to an 80 grit finish, and wiped with acetone, prior to application of the coating.

All test panels with coatings were allowed to cure under ambient Florida environmental conditions for a minimum of 2 weeks prior to testing.

The coatings used were:

- Gelcoat – Interplastic Product Code B-1435I-LMHL, an NPG-Iso based formulation, with ultraviolet inhibitor additive
- Polyurethane – BASF Product Code N300 CR, a high-solids chemical resistant formulation (2-component system)
- Polyurea – Sherwin Williams Envirolastic AR, a 100% solids elastomeric slow set formula (2-component system)
- Truck Bedliner – Line-X, a commercially available 100% solids sprayable polyurethane/polyurea formulation
- Hull Paint – Pettit Paints Inflatable Antifouling Paint #1841 (post-applied to the coatings shown above)

The coatings and method of application are shown table 9.

Table 9. Coatings and Application Methods for Biofouling Tests.

Coating	**How Applied**
Gelcoat	In-Mold
N300 CR PU	In-Mold
SW Envirolastic	Post-Applied
Line-X	Post Applied
Antifouling Paint	Post-Applied

In addition, two SharkSkin^{TM} coatings were evaluated. The SharkSkin^{TM} coatings were applied as in mold coatings that were processed like standard gel coat. Two formulations were used; these were designated SK50V and SK50G.

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Test coupons were cut from the sample panels, and antifouling paint was applied to half of the coated surface of each coupon. The coupons were then immersed in the Indian River Lagoon in Indialantic, FL. After 3- and 6- months' exposure, the coupons were removed and evaluated for strength of barnacle adhesion, and for adhesion of the coating to the fiberglass substrate.

5.1.5.2 Experimental Procedures

5.1.5.2.1 Extent of Biofouling

Digital photographs were taken of each set of test coupons upon removal from the exposure apparatus. It was not attempted to quantify the amount of biofouling. In all cases, the panel areas that were not coated with antifouling paint were heavily fouled, figure 15. The areas where the antifouling paint had been applied were unfouled, except for slime.



Figure 15 Biofouling Coupons on Exposure Apparatus.

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5.1.5.2.2 Barnacle Adhesion Test

After pressure washing (2500 psi, fan nozzle), several barnacles were removed from each coated surface using a standard test, as shown in figure 16. Reference ASTM D5618, "Standard Test Method of Measurement of Barnacle Adhesion Strength in Shear".



Figure 16 Barnacle Adhesion Test.

The test results for each coating are shown in table 10.

Table 10. Barnacle Adhesion Strength Test Results.

Coating	**Barnacle Adhesion Strength (psi)**
Gelcoat	131
N300 CR PU	105
SW Envirolastic	113
Line-X	87
SK 50V	114
SK 50G	82

The adhesion strength values represent the average of 3 tests. All tests were conducted on the fouled coating surfaces (not on the surface that was coated with antifouling paint). The tests were conducted after 3 months of immersion.

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5.1.5.3. Evaluations for Removal of Biofouling

The pressure wash was effective in removing slime, but not barnacles. A Scotch-Brite pad was also tried, to no effect. The only effective way that was found to remove barnacles was the use of a 5-In-One tool, shown in figure 17.



Figure 17 Barnacle Removal with Scraping Tool.

After scraping the barnacles off with the tool, the coated surfaces were cleaned further using a Scotch-Brite pad mounted to a battery-driven drill, figure 18.

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Figure 18 Clean-up with Scotch-Brite Pad.

5.1.5.4 Coating Adhesion Test

The adhesion of the various coatings to the fiberglass substrate was determined using ASTM D4541 "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers". The tests were performed prior to immersion, after 3 months immersion, and after 6 months immersion. The results are shown in table 11.

Table 11. Coating Adhesion Test Results.

Coating	**Control Coating Adhesion Strength (psi)**	**3-Month Coating Adhesion Strength (psi**	**6-Month Coating Adhesion Strength (psi)**
Gelcoat	1011	917	735
N300 CR PU	N.T.	1022	N.T.
SW Envirolastic	416	512	511
Line-X	864	866	594
SK50V	1070	1005	908
SK50G	1226	1387	1706

N.T. = not tested

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It is not understood why the adhesion strength of some samples, as measured, appears to increase with duration of immersion.

5.1.6 Creep Tests

Ambient, 120°F, 150°, and 165°-170°F creep testing was performed on an E-glass/vinyl ester panel, described as the 850B design in the test plan, and also on an Innegra/carbon fiber vinyl ester panel, which is described in the test plan as the Advanced design. Creep test data is presented in Appendix B to this report. The laminate schedules for the test panels are shown in table 12. The loading scheme is shown in figure 19. The test panel supporting fixture was modified so as to provide a base for the stiffening beams all the way through the sides of the support structure (see figure.)

Table 12. Creep Test Panel Laminate Schedules.

850B Panel	**Advanced Design Panel**
(mold)	(mold)
2 x 3610 0/90 E-glass	Innegra 1235 w/Trevira
4030 beam	2 x carbon 0/90 11 oz
1810 E-glass uni cap on beams	Innegra 1235 w/Trevira
2408 E-glass +/-45 overlay on beams	4030 beam
	1810 E-glass uni cap on beams
	2408 E-glass +/-45 overlay on beams

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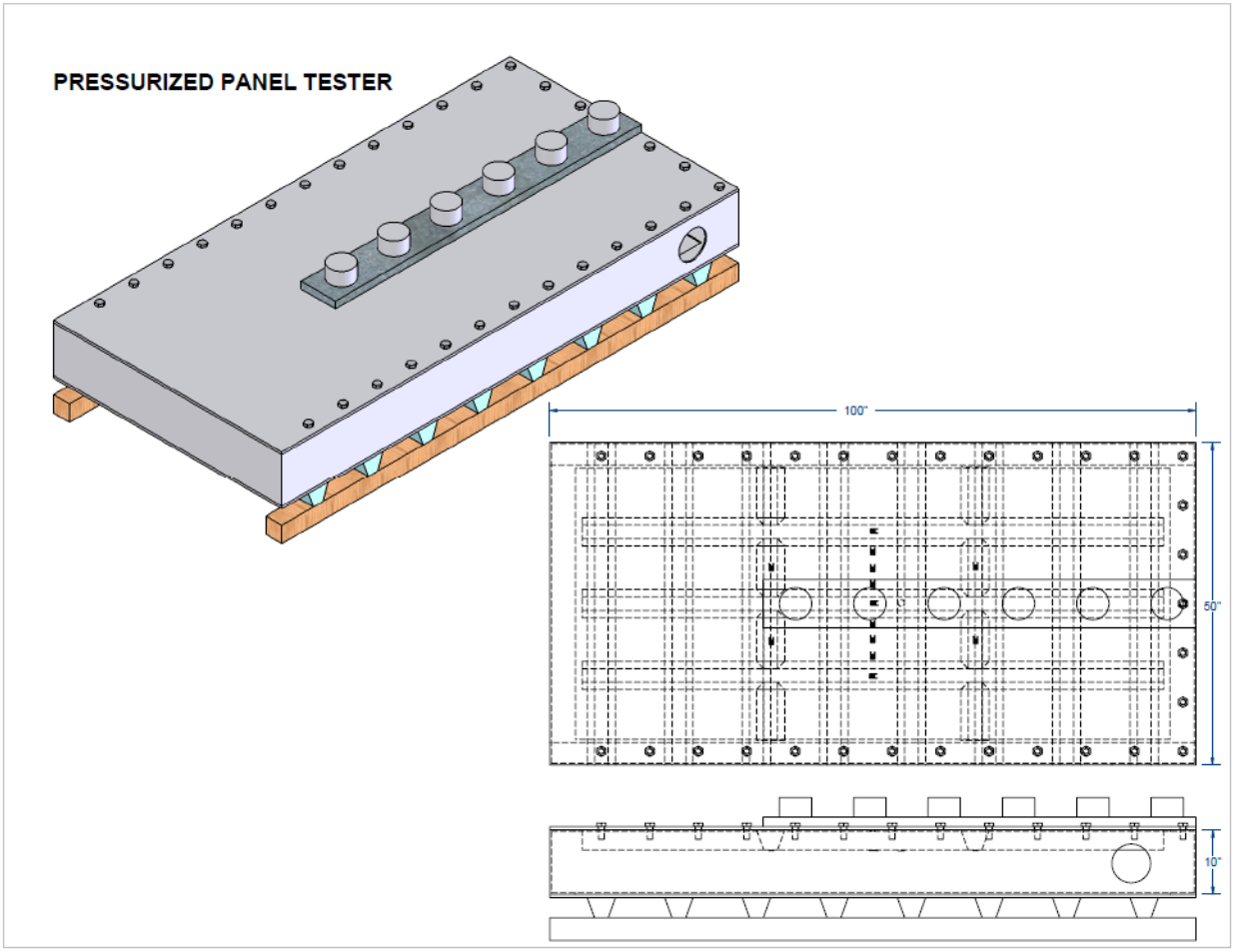


Figure 19 Schematic Loading Diagram.

The panel was bolted down to the test frame on 3 sides. The 4th side was supported, but not fixed. The deflection indicator was zeroed, and load was applied with weights, supported on a beam of 4" width by 74" length, figure 20.

The initial deflection was noted. The deflection was then recorded after 24 hours, 48 hours, and 72 hours. After 72 hours, the weight was removed. Residual deflection was noted, and was recorded again 24 hours after removal of weight.

The same panel was tested under ambient conditions, then re-tested at the higher temperatures. The applied load was 2400 pounds, distributed evenly along the length of the loading beam.

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Figure 20 Creep Test Panel Under Load.

Results of the panel creep tests are shown in tables 13 & 14 for the 850B and the advanced laminate panels, respectively. Creep test data are contained in Appendix B.

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Table 13. 850B Laminate Panel Creep Test Results.
(E-glass panel included for comparison.)

Test Temperature	Ambient (mid 80°'s F)	120°F	150°F	165°-170°F
Initial Deflection Under Load	0.187"	0.190"	0.191"	0.182"
Deflection Under Load at 24 Hours	0.195"	0.218"	0.222"	0.200"
Deflection Under Load at 48 Hours	0.198"	0.223"	0.230"	0.232"
Deflection Under Load at 72 Hours	0.200"	0.228"	0.241"	0.233"
Deflection After Weights Removed (immediate)	0.112"	0.113"	0.079"	0.090"
Deflection 24 Hours After Weights Removed	0.069"	0.088"	0.049"	0.042"

Table 14. Advanced Laminate Panel Creep Test Results.

Test Temperature	Ambient (mid 70's-low 80's °F)	120°F	150°F	165°-170°F
Initial Deflection Under Load	0.285"	0.273"	0.251"	0.265"
Deflection Under Load at 24 Hours	0.285"	0.286"	0.352"	0.285"
Deflection Under Load at 48 Hours	0.287"	0.286"	0.352"	0.298"
Deflection Under Load at 72 Hours	0.290"	0.286"	0.375"	0.305"
Deflection After Weights Removed (immediate)	0.070"	0.170"	0.135"	0.041"
Deflection 24 Hours After Weights Removed	0.041"	0.160"	0.123"	0.040"

The permanent deformation after all of the testing was approximately ¼". There was a further permanent deformation directly beneath the loading bar. This depression was approximately

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3/16" – ¼" in depth, compared to the adjacent areas. The total permanent deformation in this spot was nearly ½" in depth.

5.1.7 Resin Workability

The current resin used for fabrication of the 850 RIB is a fire-retardant, thixotropic vinyl ester formulation. As the experimental version of the RIB is fabricated using a resin-infusion process, a manufacturing trial was performed to assure that the non-thixotropic version of the resin would be suitable.

The fire-retardant resin was compared to a resin system with a long history of use in boat manufacturing. A side-by-side infusion trial was set up, using strips of reinforcement and infusion media, so that the rate of infusion of each resin could be observed and measured.

A trial was also performed using different infusion media, in order to optimize the infusion process for these resin formulations.

The experimental setup is shown in the next figure 21, and the infusion in progress is shown in figure 22.

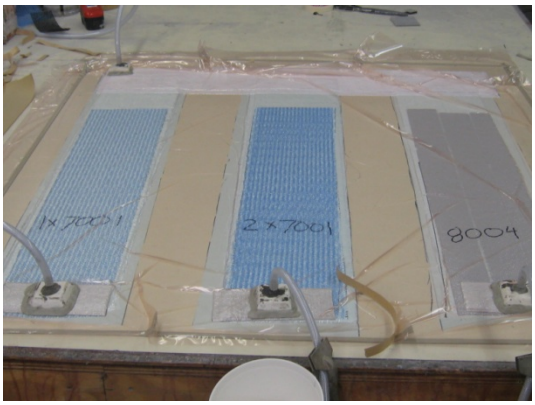


Figure 21 Infusion Media Trial Set-up.

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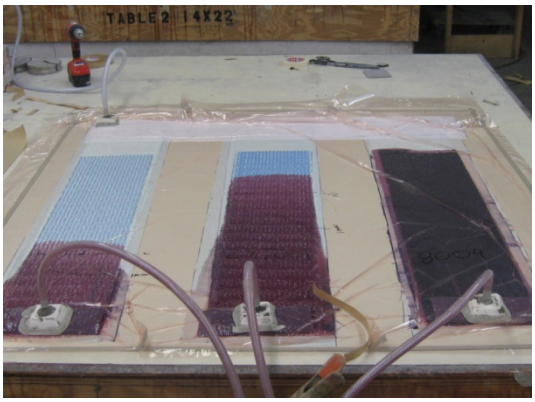


Figure 22 Test Infusion In-progress.

After testing, the infusion version of the fire-retardant resin was deemed suitable for use in the 850B boat. The full report of the manufacturing trial can be found in Appendix C.

5.2 850 Designs

The project funded two design variants for the 8.5 M craft, these were designated 850A and 850B. The 850A is a lower risk design that has a lightweight single skin construction but lacks the suspended cockpit feature found in the 850B. Thus the 850A has full height bulkheads to support the deck, while the 850B has low section transverse framing. The 850A and 850B design requirements documentation are provided in Appendix D.

5.2.1 850A Design

5.2.1.2 850A Finite Element Analysis

The design package for the 850A is presented in Appendix E. This craft was a design only, while the 850B was fabricated and evaluated. Finite element analysis (FEA) was performed with the input criteria shown below. Representative drawings and design findings for the craft are also shown below, figures 23 & 24.

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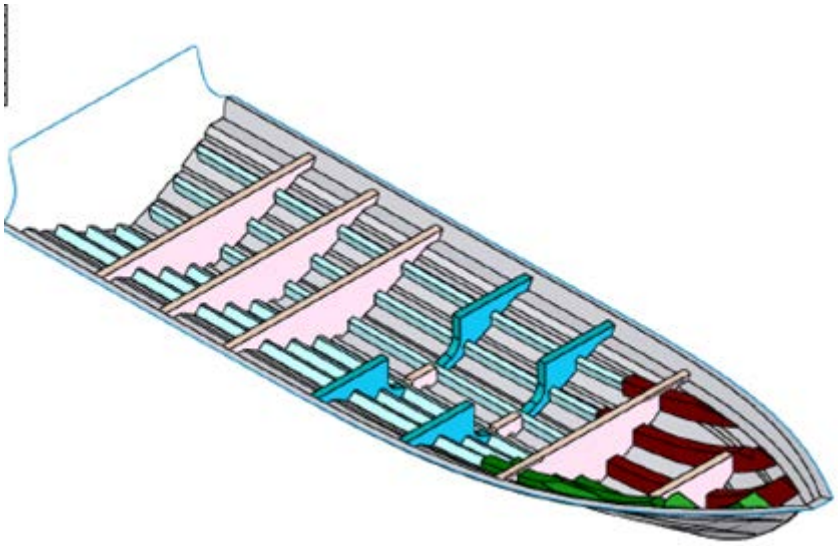


Figure 23. Hull Framing for the 850A design.

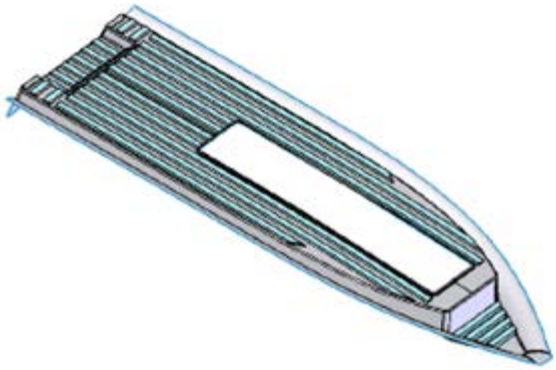


Figure 24. Deck Framing for the 850A Design.

The table 15 shows the load cases evaluated for the 850A design. With concurrence of CCD the applied pressure used was 10 psi for the small area slam evaluations. The actual pressure is not well understood; 10 psi is a reasonable load that can be easily scaled.

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Table 15. 850A Load Cases Evaluated.

Load Case	Load ID	Description	Pressure	Load
1	AMI	Aft Mid Inboard, SAS	10psi	--
2	AMO	Aft Mid Outboard, SAS	10psi	--
3	FI	Fwd Inboard, SAS	10psi	--
4	F0	Fwd Outboard, SAS	10psi	--
5	STR	Stringer, SAS	10psi	--
6	LAS	Large Area Slam	4.68psi	44,000lbs
7	CWP	Calm Water Planning	1.1psi	11,000lbs
8	BLP	Boat Lift Points	--	10,860lbs
9	GML	Gun Mount-Longitudinal	--	1500lbs
10	GMT	Gun Mount-Transverse	--	1500lbs

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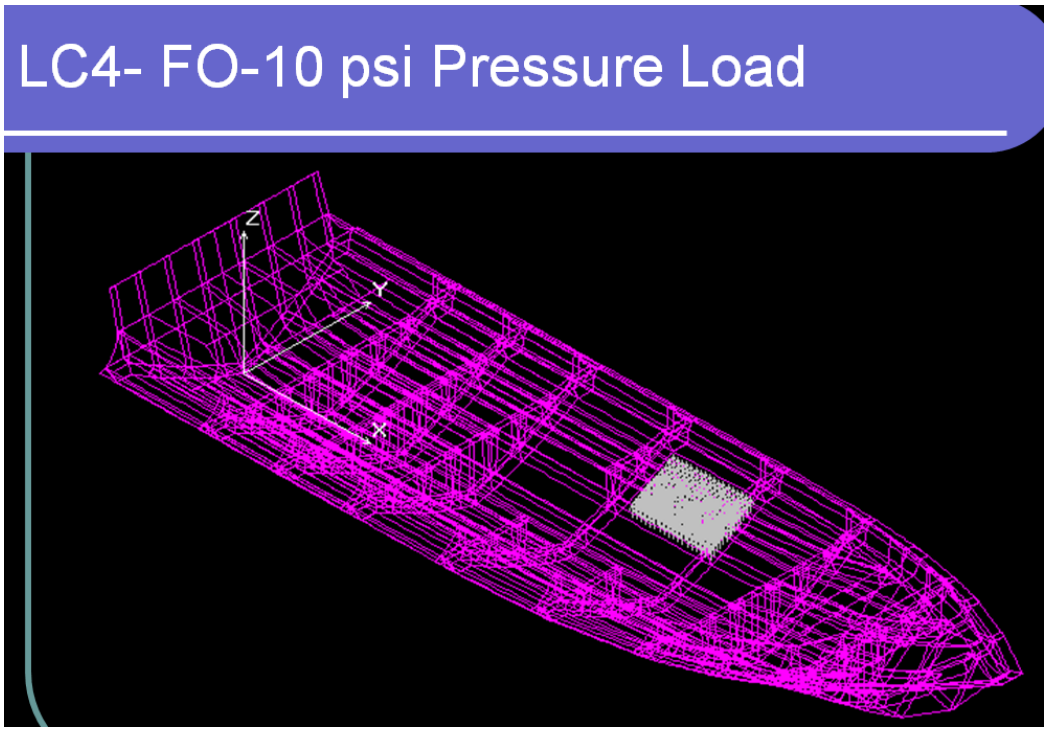


Figure 25. FEA Snapshot - 10 psi pressure load applied to shaded area.

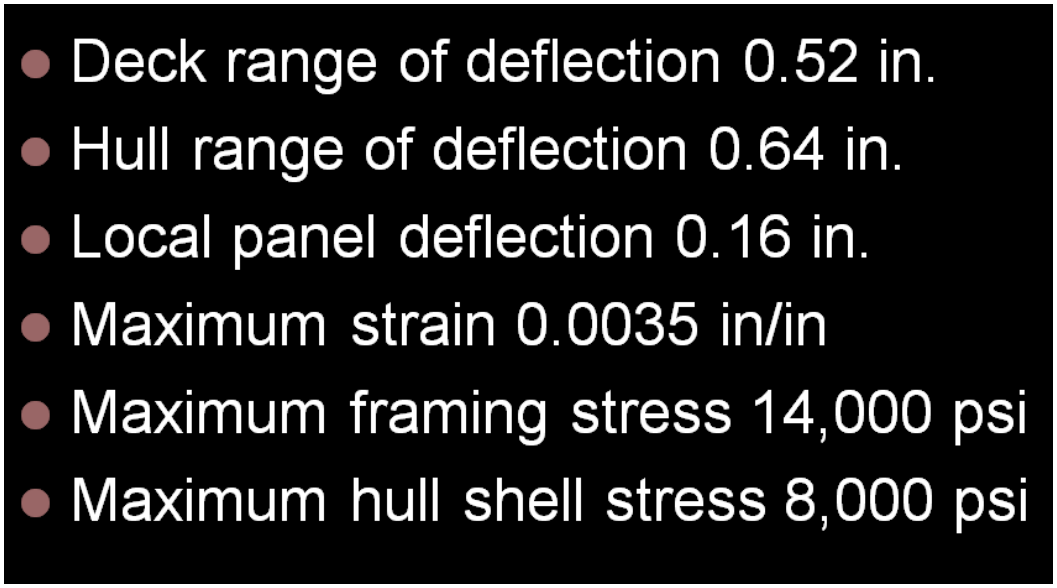


Figure 26. REA summary from the load case shown in figure 25.

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FEA analysis, figures 25 & 26, indicated that the structure as modeled would be adequate in terms of strength and stress.

Table 16. Weight Projections for the 850A.

A-Boat					
	Area (sqft)	Weight/Area oz/sqft	Weight (lb)	Rev 1 mod	Rev 2 (lb)
Hull	219.7	43.5	597	18.5	616
Deck	185.5	32.5	377	26	403
Hatch	32.1	32.5	65		65
Bulkheads	82.8	6	31		31
			1070		1115
	Length (ft)	Weight/Length (oz/ft)	Weight (lb)	Rev 1 mod	Rev 2 (lb)
Hull - TR4030	125	15.3	119		119
Deck - TR4010	130	6.0	49		49
Hatch TR4010	46	6.0	17		17
			185		185
		Rev 0	1256	Rev 2	1300
		Use Rev 0	1381	Use Rev2	1430

Table 16 above provides the weight projections for the 850A design. These are summarized and compared to the baseline and 850B designs later in the report. The design was further optimized as part of Task1 and additional weight savings were projected. With design optimization it was projected that the 850A would have a 34% weight savings from the baseline craft.

5.2.2 850B Design

The 850B RIB moderate risk design incorporates additional novel design features to meet the objectives of reduced weight and impact mitigation. These design features include:

1. Preform stiffening system; elimination of hard bulkheads and stringer systems will reduce stress risers and reduce transfer impact shock to personnel.
2. Grid system design to maintain hull shape while reducing weight, figures 27 & 28.

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3. Infusion Molding Process.
4. In-mold SharkSkin™ coating.



Figure 27 Preform Grid System.



Figure 28 Deck Underside Showing Preform Stiffeners.

5.2.2.1 Requirements of the 850B Design

The 850B design requirements document is included in Appendix D to this report. At a minimum, the requirements of the current 850 RIB designed for EOD must be met. Other requirements include:

- Hull
  - Fully loaded weight 11,900 lbs.
  - Speed 30 kts

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- Lift/Hoist
  - Weight 5600 lbs
  - FOS must be greater than 6
  - Lift point is 7’ 4” (2235 mm) above keel
  - Height above upper deck 36 inches
  - Load applied 1500 lbs

5.2.2.2 850B Representative Drawings

Figures 29 & 30 presented below are hull and deck drawings identifying locations of composite preform stiffener beams.

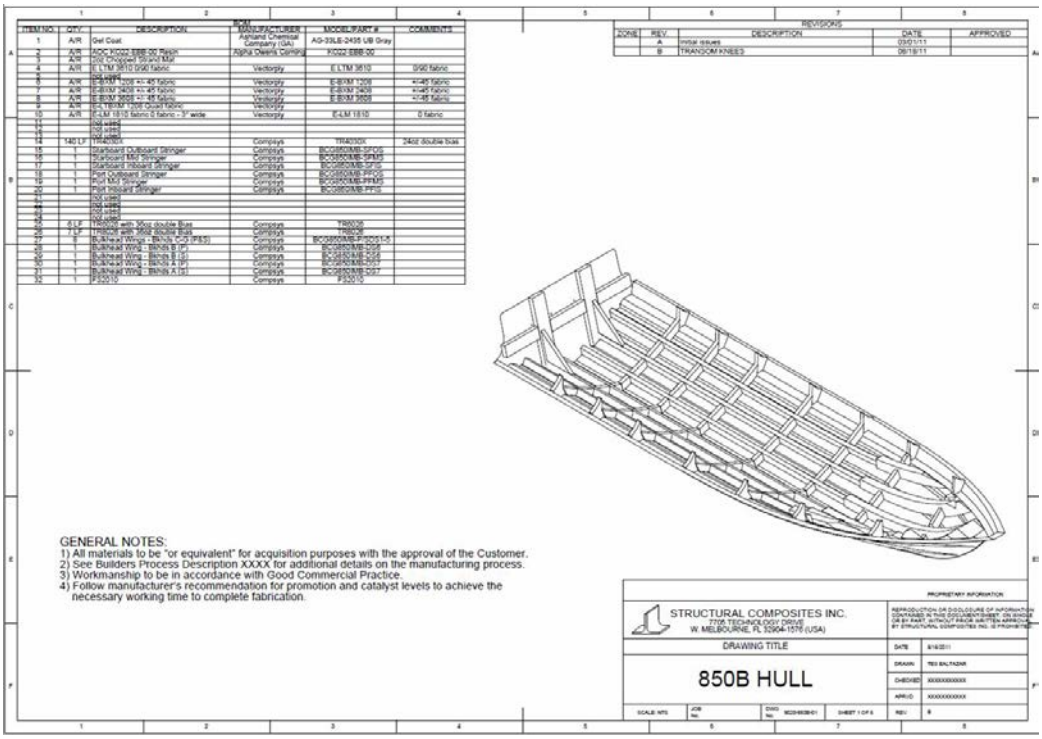


Figure 29 850B Hull Preform Stiffener Beams.

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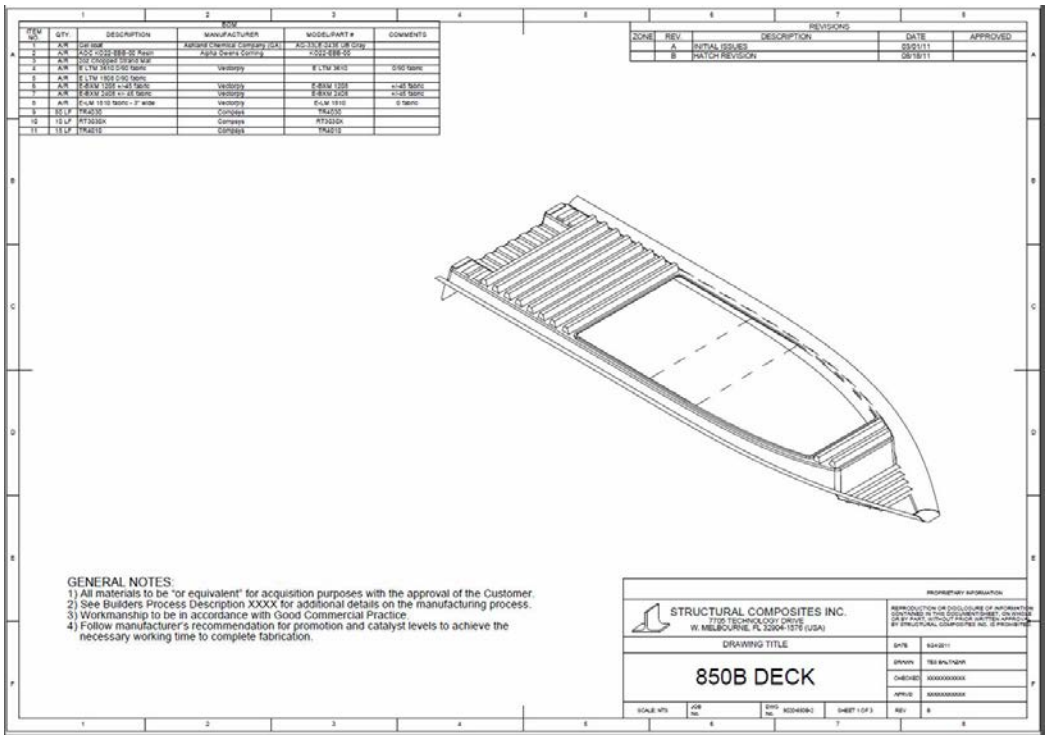


Figure 30 850B Deck Preform Stiffener Beams.

5.2.2.3 850B Design Materials

The materials utilized in the 850B fabrication included:

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 2 x 3610 (Bottom) 2x 1708 (Sides)
- Stringers – TR4030X /1810 / 1208
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 2 x 2408
- Deck Framing – TR4030 (24oz 0/90)
- Transom – Gel Coat / 2oz CSM / 1 x 3610 / Transom Preforms (24oz +/-45, bottom overlays (2 x1810), 1x 3610

A thermoset fire-retardant vinyl ester resin was used to make the parts. This was an infusion-grade formulation. The primary reinforcement was a 0°/90° E-glass knitted reinforcement, with 1 oz/ft^2 chopped strand mat stitched to one face (3610). Additional plies of knitted E-glass were used in selected areas.

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5.2.2.4 850B Finite Element Analysis

The finite element analysis inputs were based on the requirements shown above and in Appendix D. The full FEA analysis results are included in the 850B Design Presentation provided in Appendix F. A complete list of load conditions that were analyzed is provided in table 17. Representative examples of the FEA are shown in figures 31 & 32.

Table 17. Load Conditions Analyzed in 850B FEA.

Load Case	Load ID	Description	Pressure (psi)	Load (lbs)
1	AMI	Aft Mid Inboard, SAS	10	--
2	AMO	Aft Mid Outboard, SAS	10	--
3	FI	Fwd Inboard, SAS	10	--
4	F0	Fwd Outboard, SAS	10	--
5	STR	Stringer, SAS	10	--
6	LAS	Large Area Slam	5.57	52,400
7	CWP	Calm Water Planning	1.23	13,100
8	BLP	Boat Lift Points	--	33,600
9	GML	Gun Mount-Longitudinal	--	1500
10	GMT	Transverse	---	1500
11	TLA	Transom Load Analysis (Thrust/Weight)	--	6600 3072

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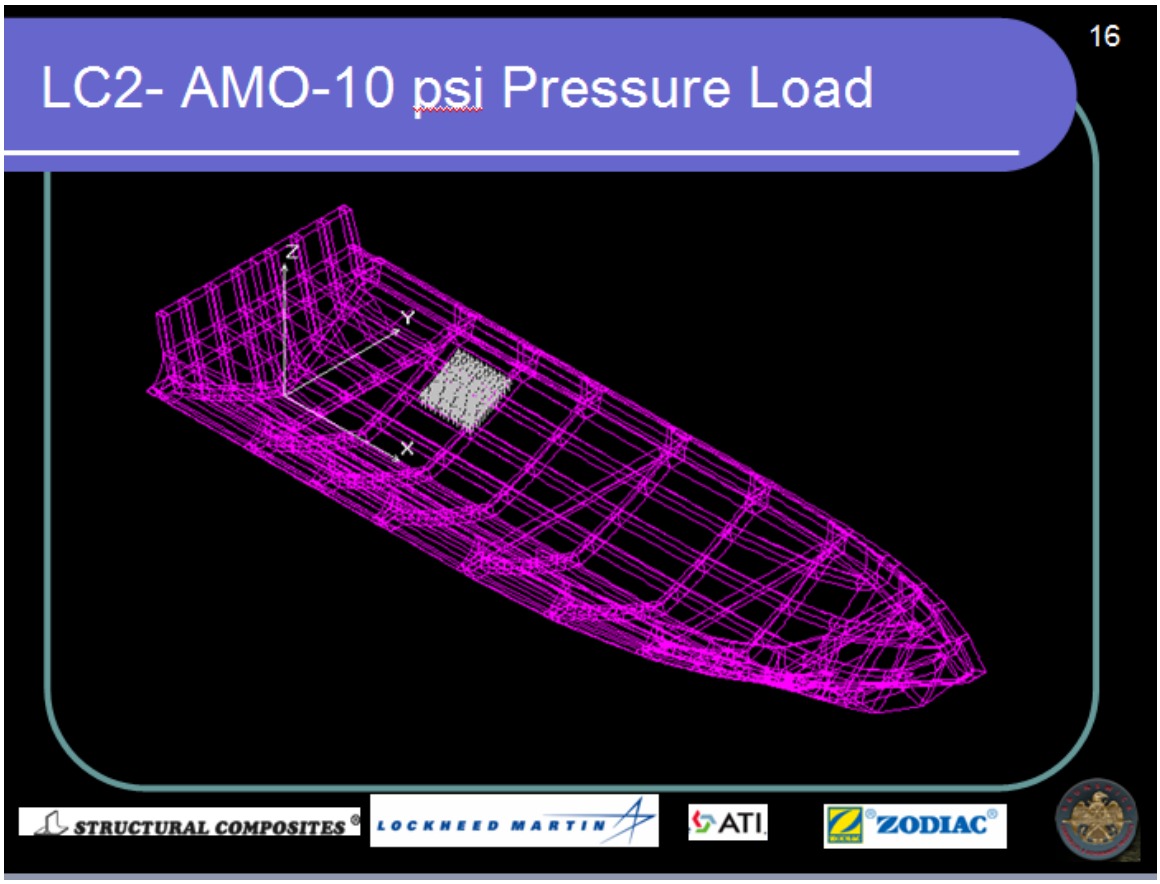


Figure 31 Hull FEA Example.

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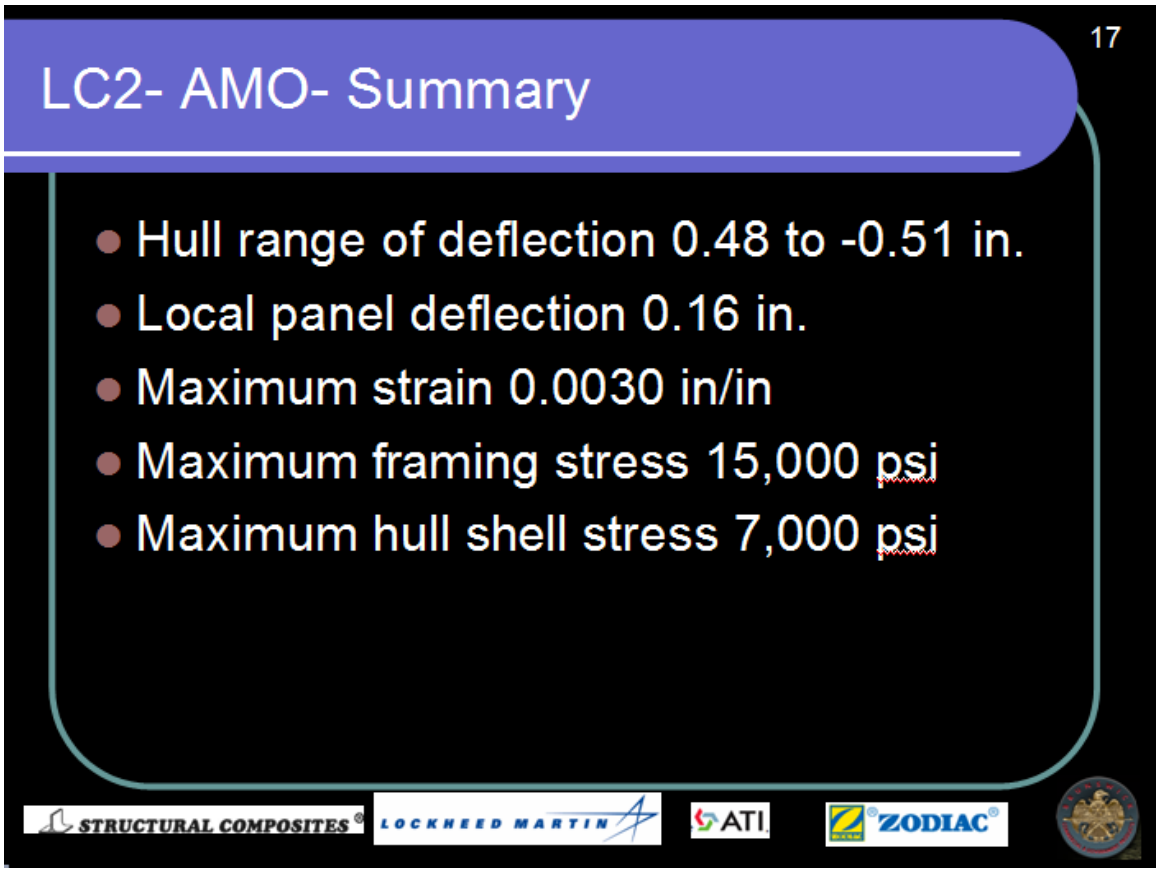


Figure 32 Hull FEA Result Summary.

5.2.2.5 Deck and Hatch Repairs

During one offshore test run fully loaded in large seas, the composite deck and hatch were damaged. Modifications were made in order to provide additional stiffness and strength in these areas. The following figures 33 - 36 show deformation, cracks, and modifications.

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Figure 33 Hatch Deformation

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Figure 34 Deck Starboard Cracks

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Figure 35 Deck Stiffening Modification



Figure 36 Hatch Modification/Rework on the 850B

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Modifications consisted of stiffening the deck in the hatch flange area. A composite part was laminated and post-bonded to the underside of the deck flange. The hatch was reworked by first bonding a polyester mat laminate to the outer perimeter. Following this, pre-molded end caps were bonded to the ends of the hatch frames. These caps extend onto the polyester mat laminate. Once this was completed new inserts were installed onto the deck and the hatch screwed into position.

5.3 850B Manufacturing

The 850B hull and deck were fabricated on site at Brunswick Commercial Products (BCP) in Edgewater, Florida. The 850B hatch was fabricated at Structural Composites, Inc. (SC) in Melbourne, Florida. In order to incorporate lessons learned into the larger parts, the smallest part, the hatch, was fabricated first. The order of fabrications was the hatch, deck then hull.

All parts were fabricated with an in-mold coating. For the hull and deck a high performance gel coat was used. For the 850B hatch a SharkSkin™ 25V experimental coating was used. Following the coating a chopped strand mat layer was hand laid into the parts. The structural laminate and framing were then infused. For the 850B hatch and deck all primary framing was included in the infusion process. For the 850B hull the longitudinal frames were co-infused with the hull laminate and the transverse framing was hand laminated. Preform gunnel gussets were hand laminated after the 850B hull and deck were mated.

The hatch of the 850B is a full deck width hatch with transverse preform framing. Figures 37 & 38 are pictures of the finished part. The part is 70 sqft of laminate with a weight of 119 lbs. This weight is included in the deck weight for the craft.

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Figure 37 850B Hatch after Infusion being removed from mold

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Figure 38. 850B hatch after trimming. Part weight 119 lbs.

The 850B deck was the next largest part, and was produced on site at Brunswick Commercial Products (BCP), figures 39-41. This allowed BCP to receive hands on infusion training.

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Figure 39 850B deck with vacuum bag in place.

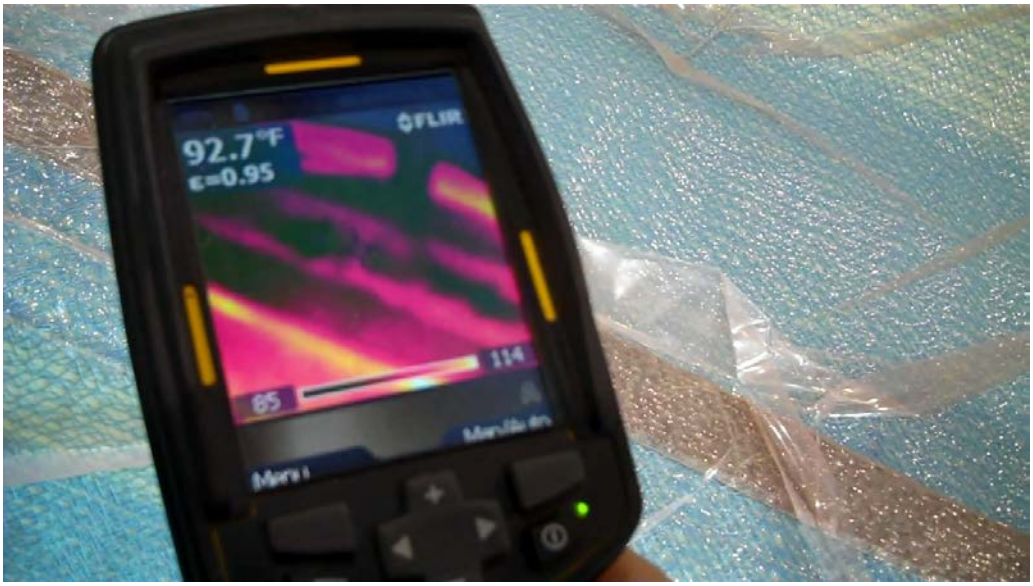


Figure 40 Thermal Imaging for vacuum bag leak detection.

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Figure 41 850B Deck Undergoing Infusion.

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Figure 42 Infused deck of the 850B.

The deck was successfully infused and removed from the mold, figure 42. The hull was the final part fabricated on the 850B. This was also performed at BCP, figures 43-45. The part was infused with just the longitudinal framing to minimize process risk. Later in the project the 11M prototype was fabricated with both the longitudinal and transverse framing infused. Both methods are viable, however it is easier and lower risk to infuse the longitudinal frames separately.

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Figure 43 850 hull fabrication - leak testing



Figure 44 850B hull infusion

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Figure 45 850B Hull complete with transverse frames installed

The hull was successfully infused. An opportunity for improvement was noted in the area of the radius of the beam to the hull. In some areas bridging was noticed. This problem was eliminated during later fabrication of the 11M prototype through the more precise placement of overlay layers and ensuring ample bag material to prevent bag bridging.

The weight results of the manufactured 850B parts are shown in table 18. Significant weight savings were achieved over the baseline craft. The baseline craft was hand laminated; this craft was infused, so additional labor was expended. In discussions with the builder they felt the cost savings from materials would approximately offset the increased labor and expendables with a trained experienced production crew.

Table 18. Weight Results After Fabrication and Trimming.

Fabricated Boat	**Weights (lb.)**	
	Baseline 850	850B
Fabrication Method	Open Mold Hand Layup	VARTM
Hull	1267	760
Deck	702	399
Console	540	350
Total	2509	1509
% Current	100%	60%
% Savings	-	40%

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5.4 850B Craft Performance Evaluations

The 850B prototype underwent performance evaluation was tested to establish the overall craft characteristics and to determine the structural performance of the craft. Evaluations consisted of testing the craft while on the trailer, in calm water and in offshore ocean conditions. Appendix G contains the complete test plan, a summary is provided in the following sections.

5.4.1 850B Instrumentation and Sensor Locations

The 850B was outfitted with accelerometers, strain gauges, string pots (to measure hull to deck deflections) and air pressure monitors. Figures 46-48 show the locations and identification codes for each of the sensors.

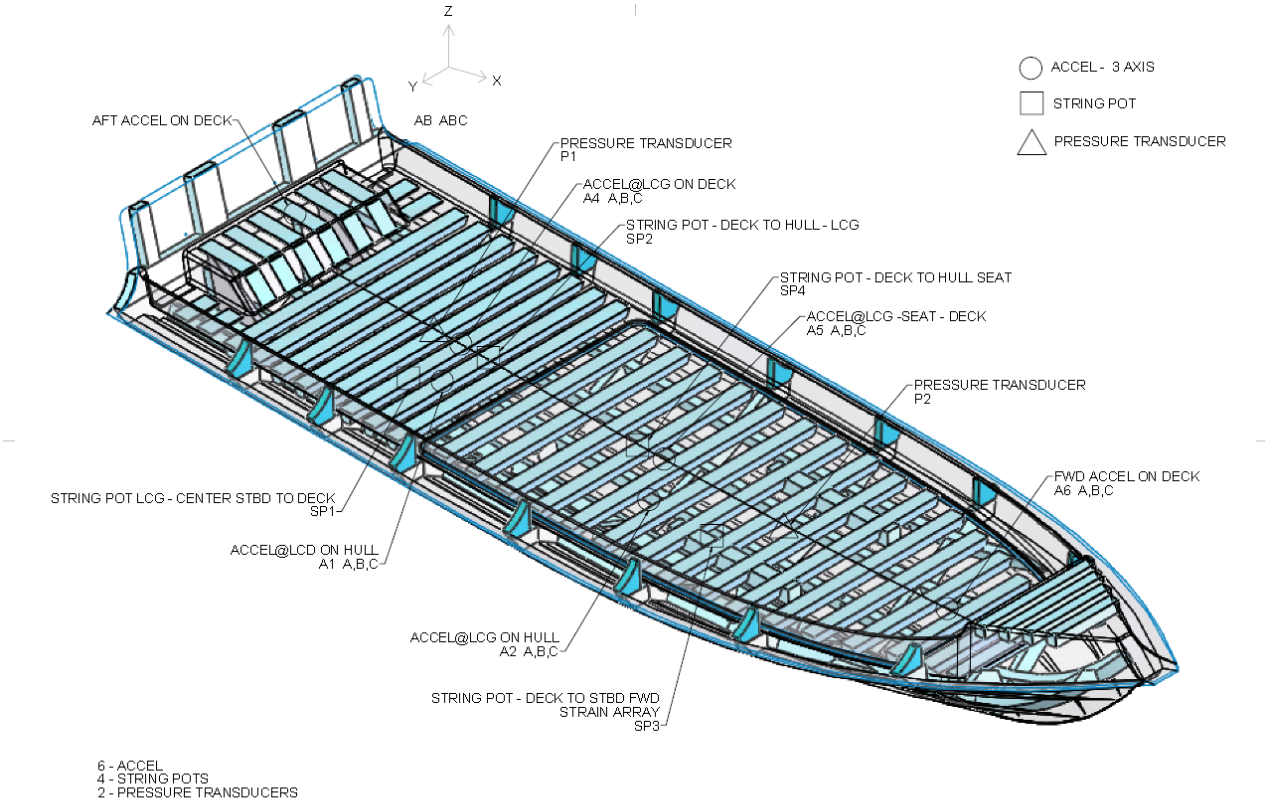


Figure 46 Locations of Accelerometers, String Pots and Pressure Transducers

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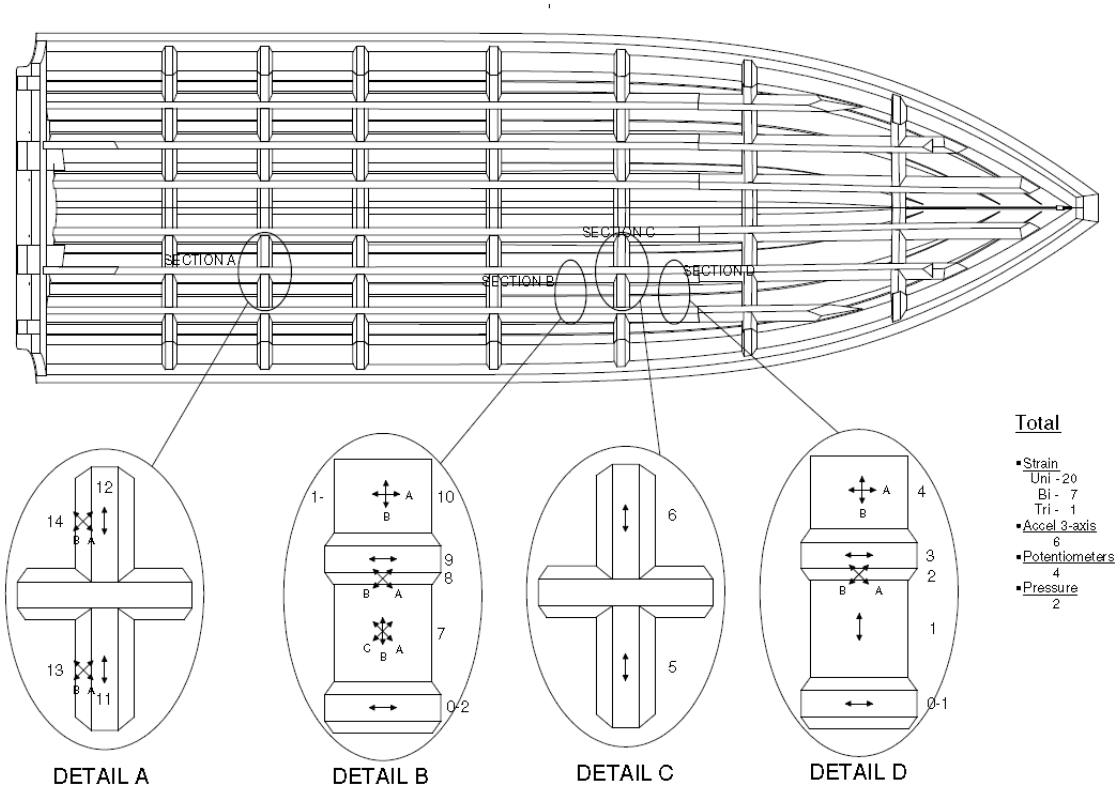


Figure 47 Location and Orientation of Strain Gauges on the 850B Hull

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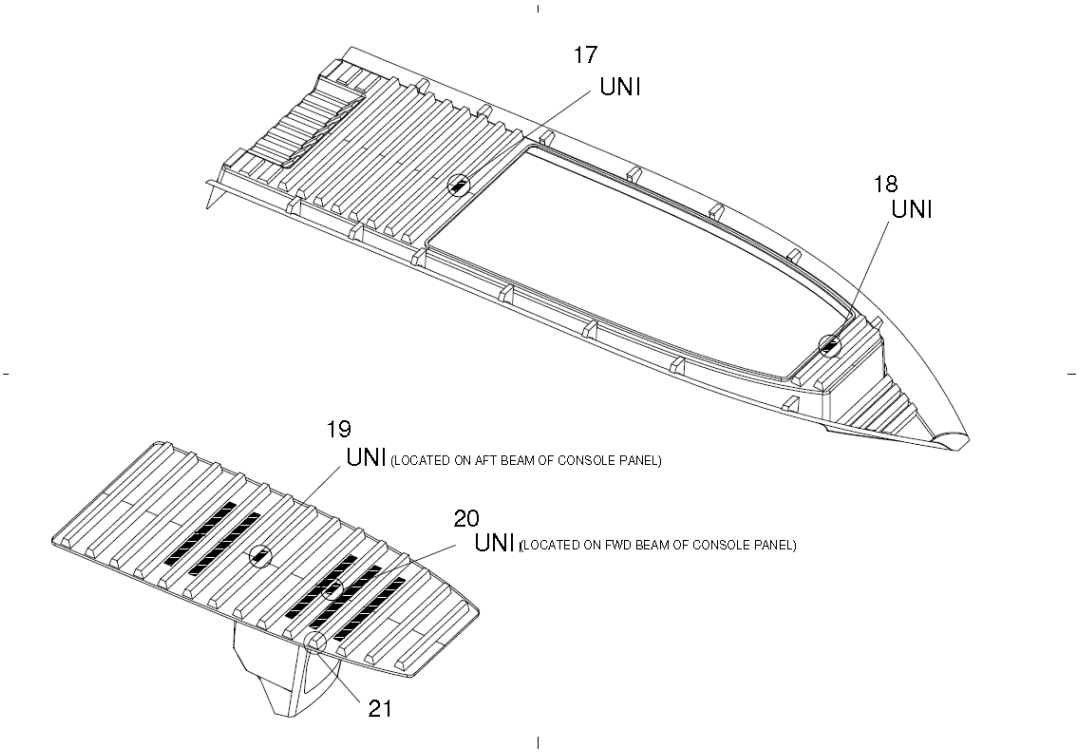


Figure 48 Location of strain gauges on the underside of the deck/hatch of the 850B

Six (6) accelerometers were placed on the craft. Two of these were placed on the hull bottom framing, one at LCG and the other under the helm station. The hull bottom gauges had a full scale range of 25g. Two accelerometers were placed on the deck above the hull accelerometers. These gauges had a full scale range of 10g. The placement of these accelerometers allowed for the determination of the acceleration response of the hull and deck during shock loads due to wave impacts. Two additional 10g accelerometers were placed on the deck, one on the bow and the other on the stern. All of the above accelerometers were three-axis MEM type accelerometers.

Four (4) Unimeasure waterproof string-pots, figure 49, were installed in the craft to measure deflections.



Figure 49 Unimeasure waterproof strain pot

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Two of these devices were located between the keel and the deck. These were closely located to the LCG and Helm station accelerometers. Two of the devices were located between the hull mid panel and the deck. One forward mid-panel deflection measurement point coincided with the location of the hull strain gauge array, and the other mid-panel deflection measurement point was starboard of LCG.

The design of the 850B creates an air plenum between the hull and deck. SC performed limited experiments with the 850B pressurizing the hull with a 2 hp air blower. Hull air pressure was monitored during both pressured and non-pressured testing using two Omega PX140 series differential pressure gauges (1psi range), figure 50.

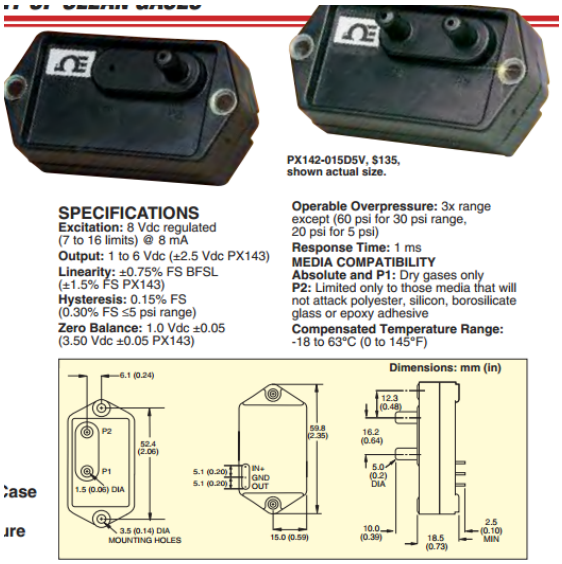


Figure 50 Omega PX140 series differential pressure gauge.

Strain gauges were located at key locations on the hull and deck of the 850B as shown in figures 47-48. These included the following:

- Cap of Stringers-impact zone forward of amidships
- Transverse frame Cap- impact zone forward of amidships
- Panel- edge of stringer (sidewall) – impact zone
- Panel- center of panel- impact zone
- Deck- FEA area of interest
- Hatch- Mid-span-Cap of Frame
- Transom- Sidewall of Transverse Frame

Table 19 below shows the strain gauge type, location on the structure, and quantity.

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Table 19. Strain Gauge Type, Location, Quantity.

Type	Hull	Deck	Hatch	Transom	Total
Unidirectional	9	2	2		12
Bidirectional	6			2	8
Triaxial	1				1

A National Instruments Compaq RIO system was used to collect data during the evaluations. The system was configured to collect data at a rate of 100 samples/second. Attached to the RIO was a GPS system to provide location and speed information.

5.4.2 850B Loading Conditions

Two primary loading conditions were used for the evaluations. These are lightly loaded and the heavier of the fully loaded conditions. The light load condition is the craft in the hoist condition. The two loaded configurations are the threshold load condition and the objective load condition. Load conditions were achieved by adding simulated weight to the craft with water bags. Tables 20-22 below show the various loading conditions. Both the VBSS objective weights and the 850B loaded weight are used.

.

Table 20. Loading Condition - Hoist.

Hoist Condition					
		VBSS Concept	**850B**	**Notes**	
		(lb)	(lb)		
	Dry Boat	4215	3630	added weight of 85 gal alumium tank	
	Fuel (50)	348	348	50 gal fuel in tank	
	Coxswain	200	200		
	PAX	800	800		
	Total	**5563**	**4978**		
			585	lbs below threshold for DDG	
			159	approx wt to increase fuel tank size to 140gal	
			426	lbs below threshold with 140gal fuel tank	
			61	gals of additional fuel (total fuel 111 gal)	
	LCG	6.8 ft	6.7	(LCG in ft without fuel or 85g tank)	

For the hoist condition the craft will be loaded to the VBSS Concept weight, as it is desired to deploy the craft with the maximum amount of fuel.

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Table 21. Loading Condition - Full Load Threshold.

Full Load Conditon Threshold									
		VBSS Concept		**850B**	**Notes**				
		(lb)		**(lb)**					
	Dry Boat	4215	w/tank	3420	dry boat no tank				
				404	appox wt of 140 gal fuel tank (linar extrapolation)				
	Fuel (140)	974		974					
	Coxswain	200		200					
	PAX	5600		5600					
	Total	**10989**		**10598**					

The full load threshold weight will be 10,600 lbs and the full load objective weight will be 10,990 lbs. The table below shows the 850B configured to objective weight. The difference is a desired larger fuel tank and larger fuel load. The full load objective weight was used for the fully loaded evaluations.

Table 22. Loading Condition - Full Load Objective.

Full load Condition Objective									
		VBSS Concept		**850B**	**Notes**				
		(lb)		**(lb)**					
	Dry Boat	3937	w/tank	3420	dry boat no tank				
				519	appox wt of 180 gal fuel tank (linar extrapolation)				
	fuel 180	1252		1252					
	Coxswain	200		200					
	PAX	5600		5600					
	Total	**10989**		**10991**		0.02%			

5.4.3 850B In-Water Trials

In-water trials included calm water performance evaluations, controlled wave jumping and at sea tests. The largest loads were seen when operating in ocean conditions in the fully loaded condition. Ocean trials occurred over several days allowing for a range of sea states. Wave conditions during testing off Port Canaveral, Florida ranged from 1 ft seas to as large as 5 ft seas, as measured by the nearby wave buoy.

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5.4.3.1 850B Calm Water Testing and Results

Calm water testing allowed us to determine the craft's performance in terms of speed, fuel consumption and RPM. A series of runs were made in very light condition, light condition (Hoist) and at the full load condition. At the request of the TPOC the vessel was also tested with a simulated engine failure in the hoist condition (one engine off and tilted up), figure 51. Appendix H contains hoist test results, and Appendix I contains the narrative from the calm water tests.



Figure 51 850B in single engine configuration - simulated engine failure

The craft basic performance data presented in figures 52-56 below was collected by video recording the boat's primary instruments. Values were obtained by reviewing the video.

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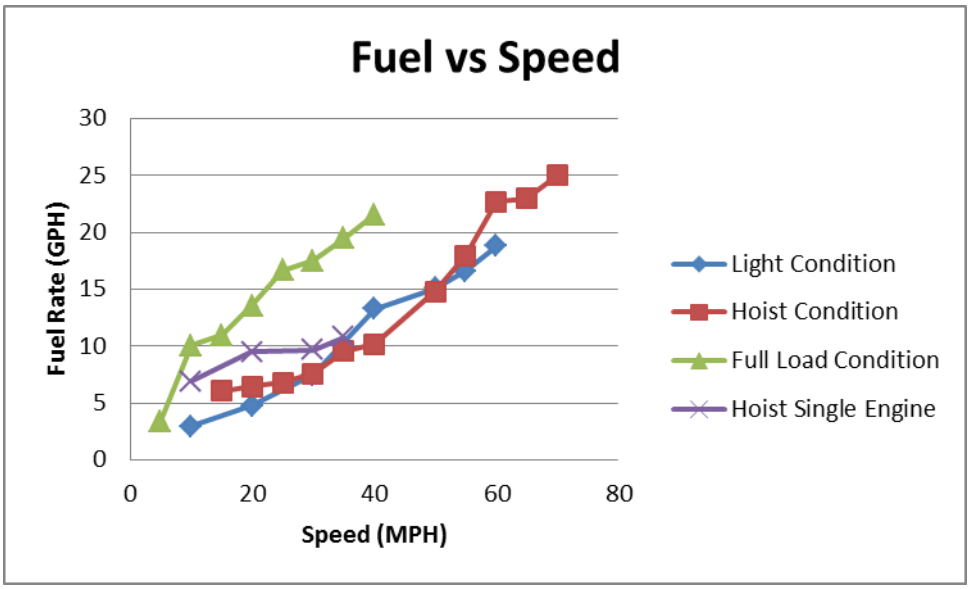


Figure 52 Fuel vs. Speed Plot for the 850B Calm Water Conditions

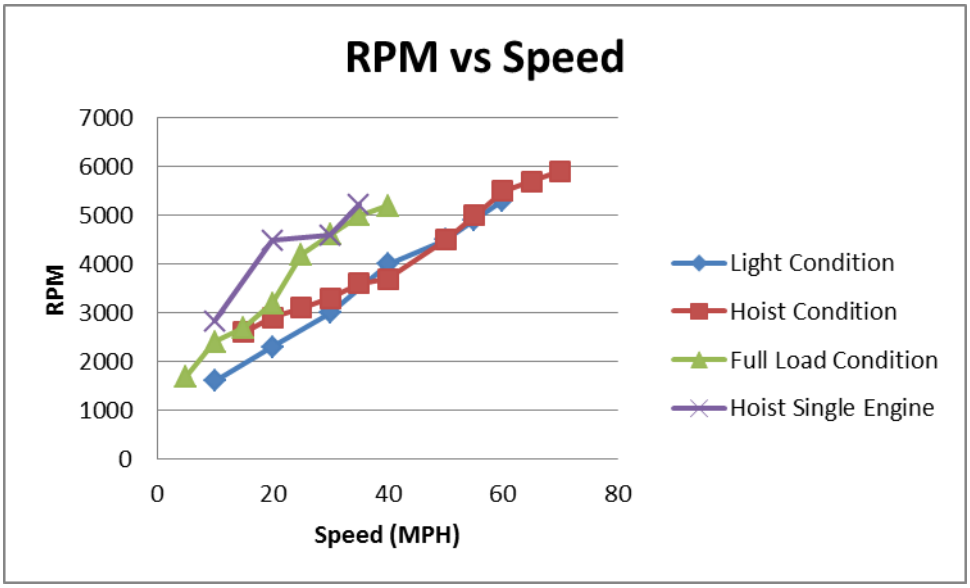


Figure 53 RPM vs. Speed for the 850B in Calm Water Conditions

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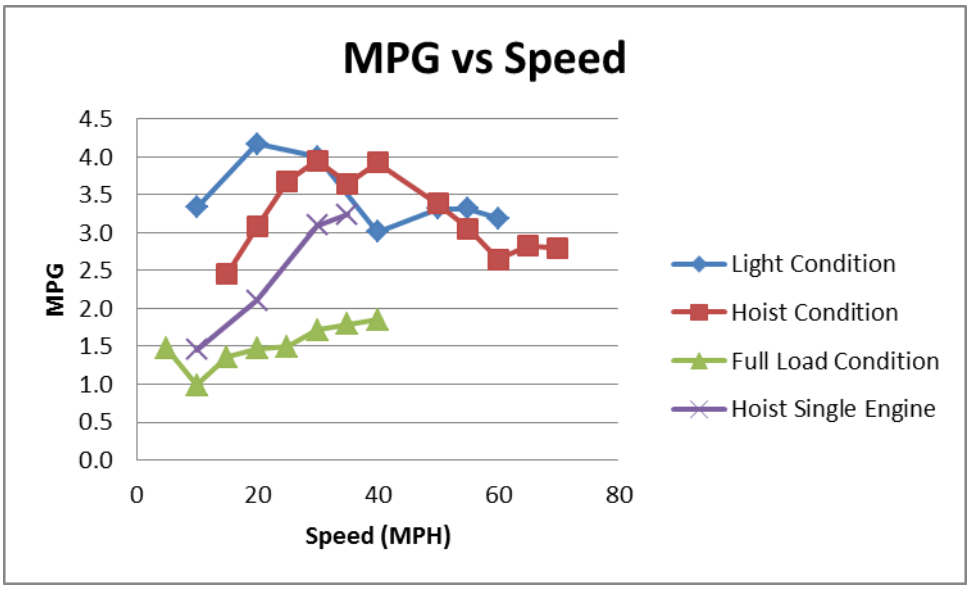


Figure 54 Miles Per Gallon Fuel usage rate for the 850B in Calm Water Conditions

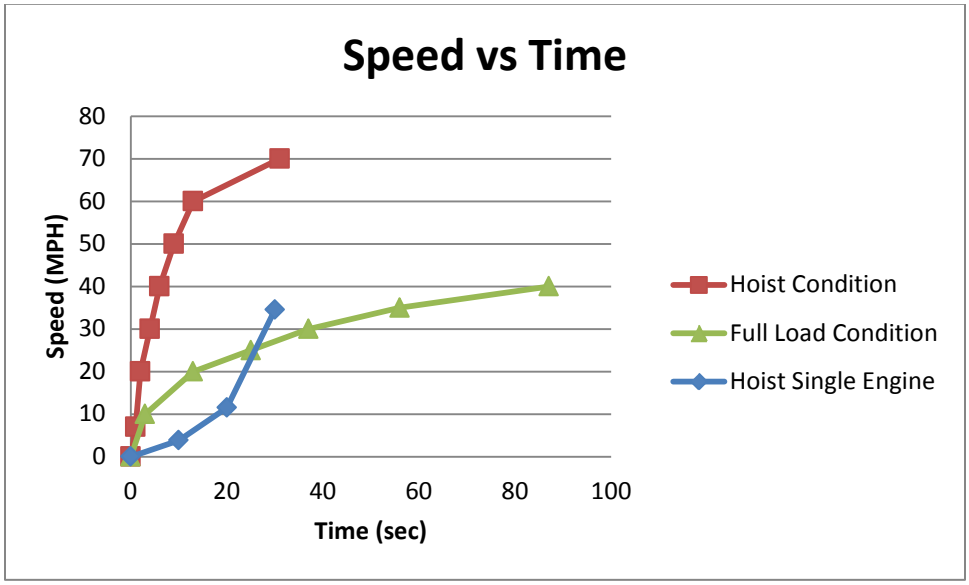


Figure 55 Acceleration data for the 850B in Calm Water Conditions

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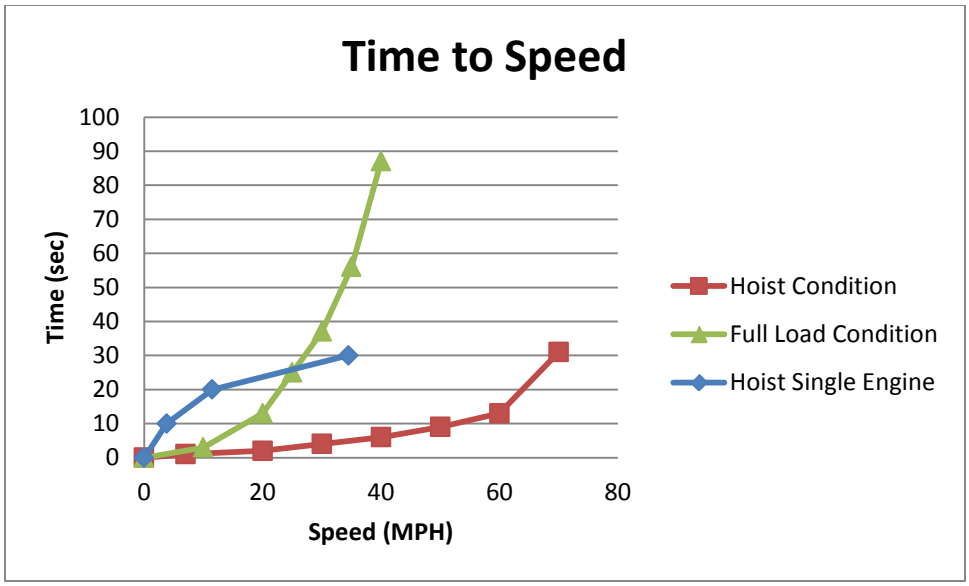


Figure 56 Acceleration data for the 850B in Calm Water Conditions

5.4.3.2 Discussion of Basic Performance Data

The 850B is a high performance craft. In the lightly loaded and hoist conditions the boat instantly gets on plane and accelerates to 50 MPH in 10 seconds. In the fully loaded condition the boat accelerates reasonably and is able to obtain the VBSS target speed of 35 knots. In simulated engine failure, in the hoist condition, the boat is able to get on a plane on a single engine. The full load condition was not tested in simulated engine failure, but based on the performance in hoist condition it is anticipated that the craft would not be able to plane fully loaded with a single engine.

The fuel efficiency of the craft is excellent. In the hoist condition at 40 MPH the craft is getting approximately 4 MPG. The good fuel efficiency is due to the combination of the lightweight hull and deck structure and the lightweight JP fuel outboards. The twin JP outboards perform very well with this craft; we see advantages over the standard inboard diesels beyond the weight and efficiency gains.

5.4.3.3 Craft Evaluations - Data Presentation

Sixty-nine (69) runs including Ocean, River, Inlet, Trailering and Air Support have been processed and are included the appendices to this report. Runs are grouped as follows:

Appendix J - Ocean Runs- Full Load, Hoist Load
Appendix K - River and Inlet Runs- Full load, Hoist load

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Appendix L – Trailer Testing
Appendix M - Air Support Trials
Appendix N- Mayport Trial Run (14 persons on board)

5.4.3.4 850B Structural Performance - Ocean Runs

The 850B was evaluated in the Atlantic Ocean off Port Canaveral, Florida. Operations occurred near NOAA Waverider Buoy Station 4113 (28.400N 80.530W). Runs were conducted in both the full load and hoist conditions over several days. Sea states during the different days give us a range of operational conditions ranging from calm seas, 1.5 ft seas, 2.5 ft seas and 5ft seas. The loading conditions were greatest when the boat was in ocean conditions in the fully loaded condition. Loads during ocean conditions created the highest strain, hull to deck deflections and vertical accelerations when compared to tests performed in intercoastal conditions and during trailer testing.

Selected runs are presented below in more detail along with discussion of the data obtained.

The following run was made offshore Port Canaveral Florida on 25 September 2012. The craft was in the full load condition, speed ranged from 25-35 MPH. Sea conditions were 2.3 to 2.7 ft wave height with smooth regular period waves (7.9 second dominant wave period). GPS was in-op.

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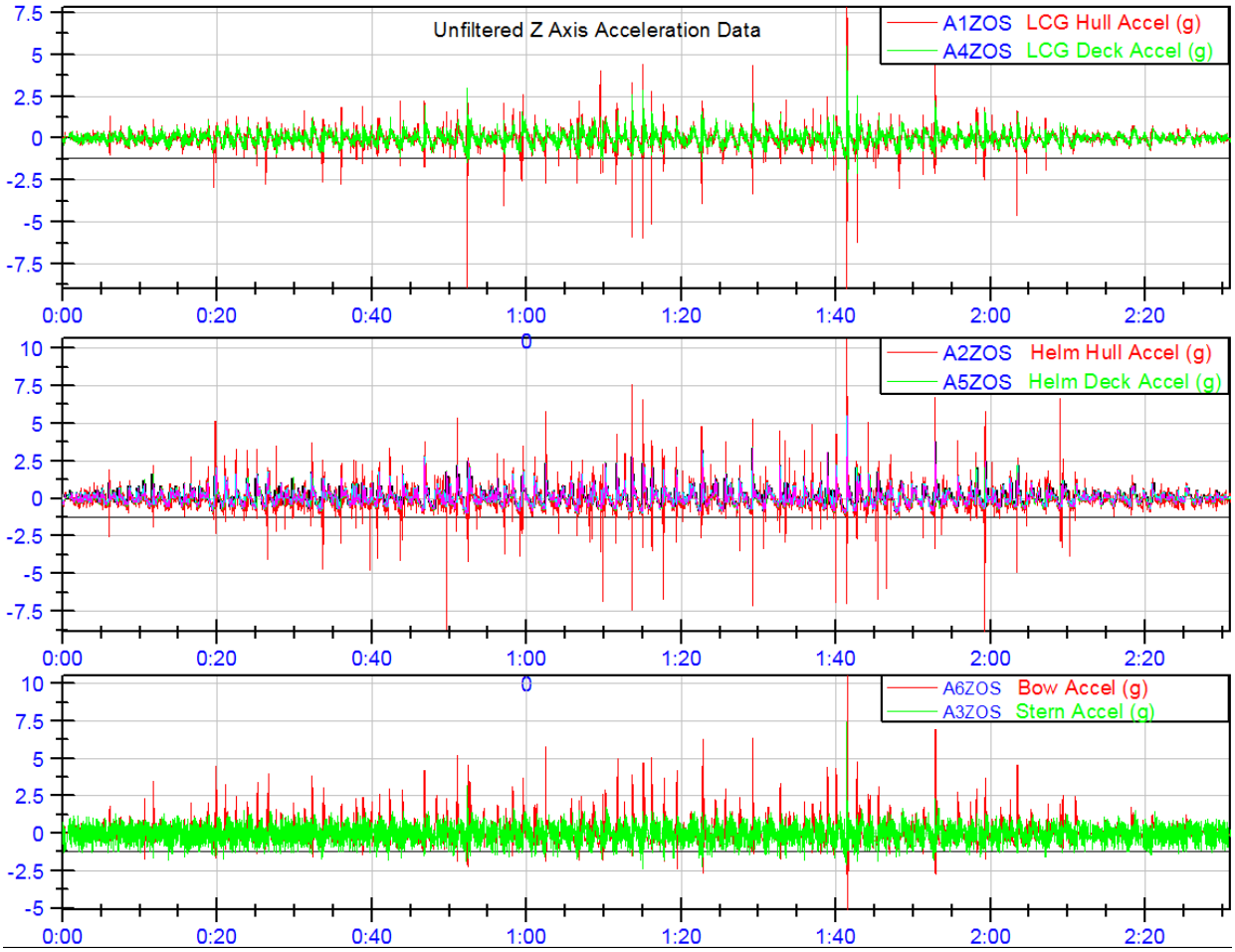


Figure 57 Full Load Ocean Run - Raw Vertical Acceleration Data

The plot above (figure 57) shows the raw acceleration data from this ocean run in the fully loaded condition. A significant slam event occurred just after 1:41 seconds and is expanded in the figure that follows (figure 58).

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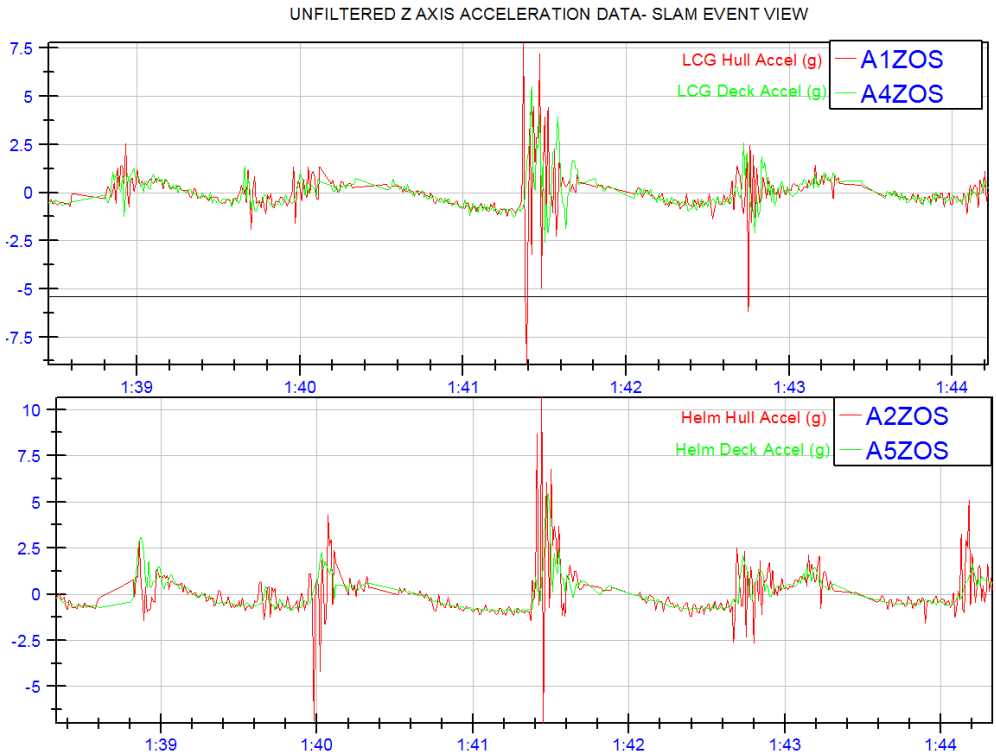


Figure 58 Raw Vertical Acceleration data for the slam event (PC25 Sept -Ocean-Full Load)

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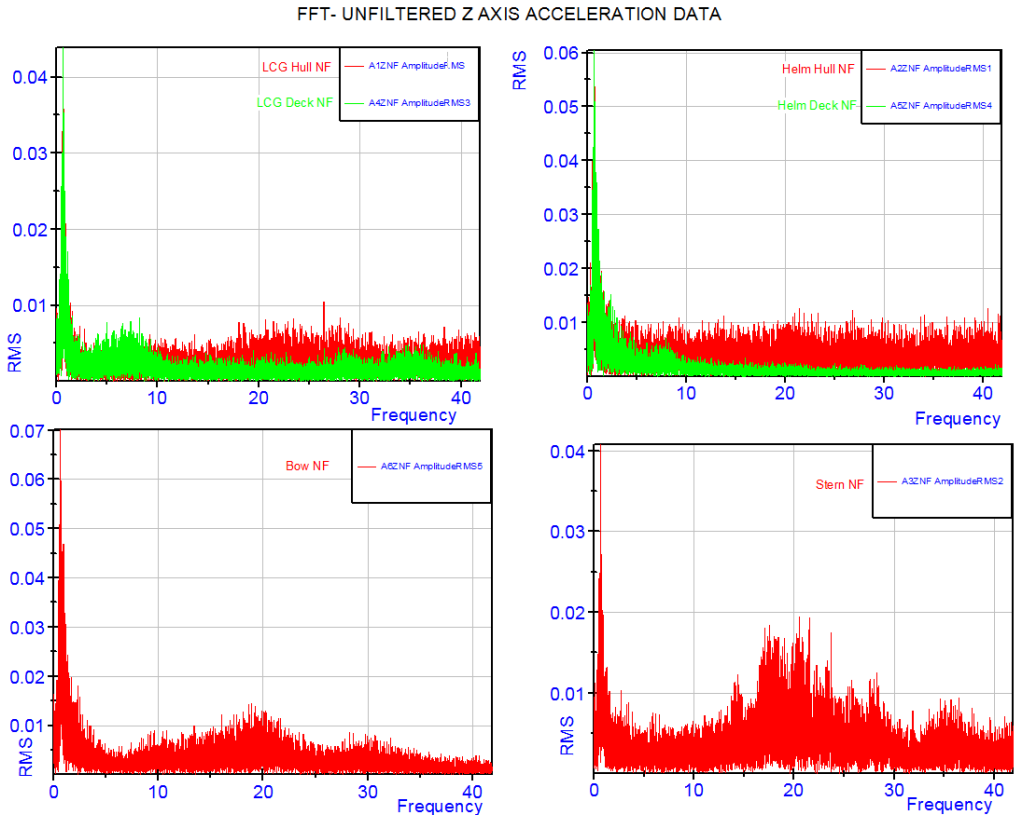


Figure 59 Fast Fourier Transform (FFT) of the raw acceleration data (PC25 Sept-Ocean-Full Load)

The figure above (figure 59) shows a Fast Fourier Transform (FFT) - Root Mean Square (RMS) of the raw acceleration data. The raw data and FFT indicate significant decoupling of the hull and deck structures. Also interesting is the behavior of the hull and deck as they are not rigidly connected. The hull structure appears to be excited by the wave impact and vibrates independent of the deck. The result is some very large negative G readings for the hull as the structure responds to the impact event. Also interesting is the reduction in peak G loads for the deck mounted accelerometers at LCG and the helm station.

The FFT data shows that the deck structure has a natural frequency of approximately 8 Hz. Also shown in the FFT data is that the deck appears to act as a low pass filter, reducing high frequency accelerations. Looking at the close up view of the raw acceleration data and looking at the hull mounted accelerometers, it appears the hull structure has a natural frequency of about 20 Hz. Frequency histogram plots of the raw acceleration data are shown below, figures 60-61.

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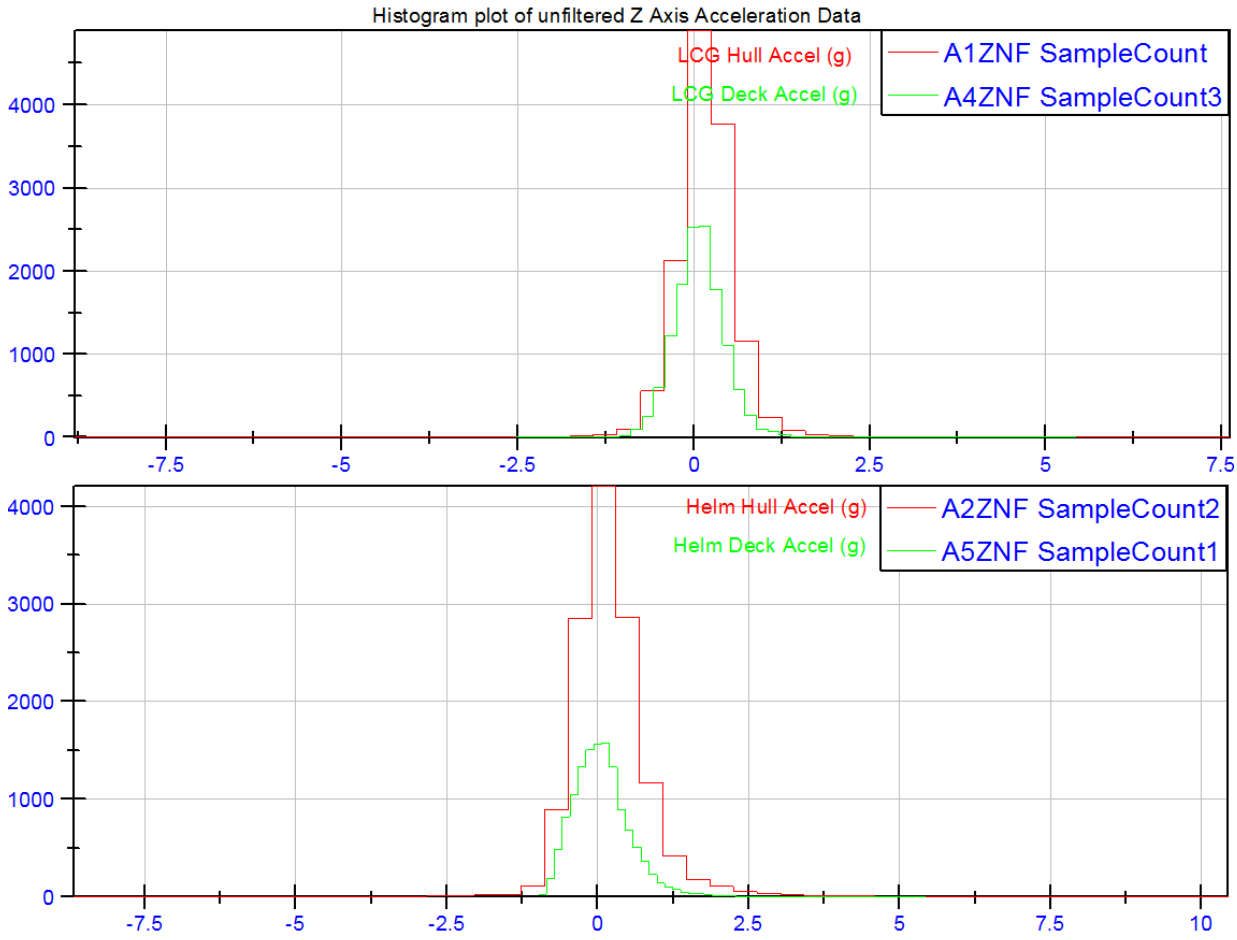


Figure 60 Histogram plot of the unfiltered vertical axis acceleration data (PC25 Sept-Ocean-Full Load)

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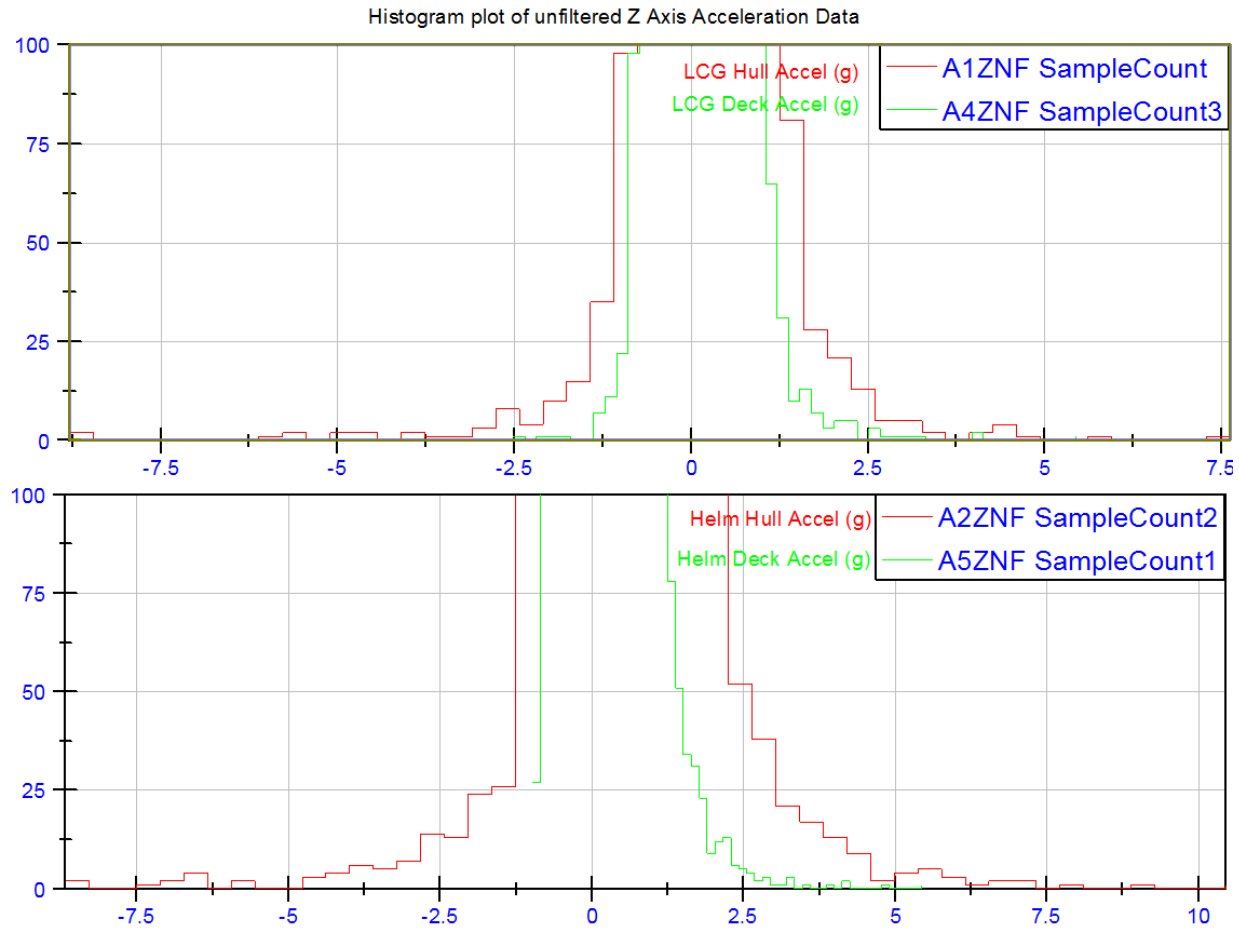


Figure 61 Zoom view of Histogram Plot of Vertical Acceleration (PC25 Sept-Ocean-Full load)

The histogram plots show the distribution of the peak accelerations of the raw acceleration data for the sensors on the hull and deck at LCG and the Helm station. The plot above is the same data but magnified to view the larger accelerations. The plots indicate that the deck accelerations are of lower amplitude and have fewer peaks when compared to the reading taken on the hull.

The vertical acceleration data after performing a 20 Hz butterworth low pass filter on the data are presented below (figures 62-63). The 20 Hz frequency was recommended by the data experts at Combatant Craft. As shown in the figures, even with the 20 Hz filter we see reductions in the peak accelerations at the LCG and deck mounted accelerometers vs. the hull mounted accelerometers. These plots support the same conclusions.

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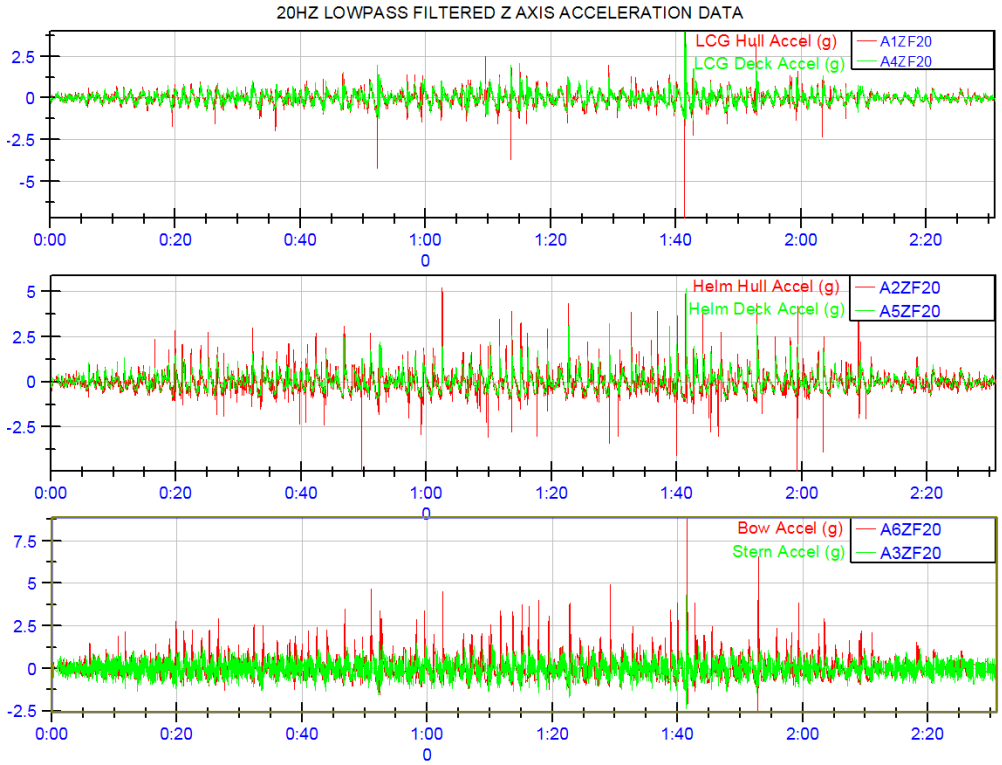


Figure 62 - 20 Hz Butterworth Low Pass Filter of the Vertical Acceleration Data (PC25 Sept - Ocean-Full Load)

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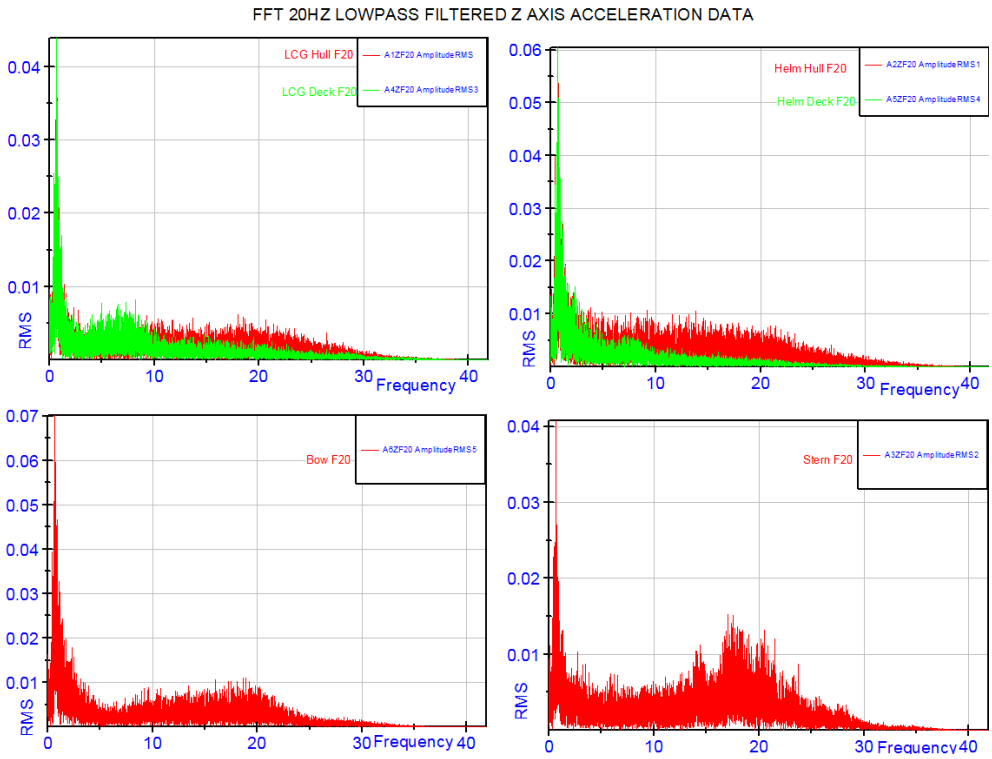


Figure 63- FFT on the filtered vertical acceleration data (PC25 Sept-Ocean-Full Load)

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The figure below (figure 64) shows the raw data from the four string pots placed between the hull and deck of the 850B. The devices were set to zero prior to adding weight to the deck so the 0.4 inches represents the static deflection due to bringing the boat to the fully loaded condition. The maximum deflection was approximately 1.25 inches, of which 0.85 inches is the dynamic deflection.

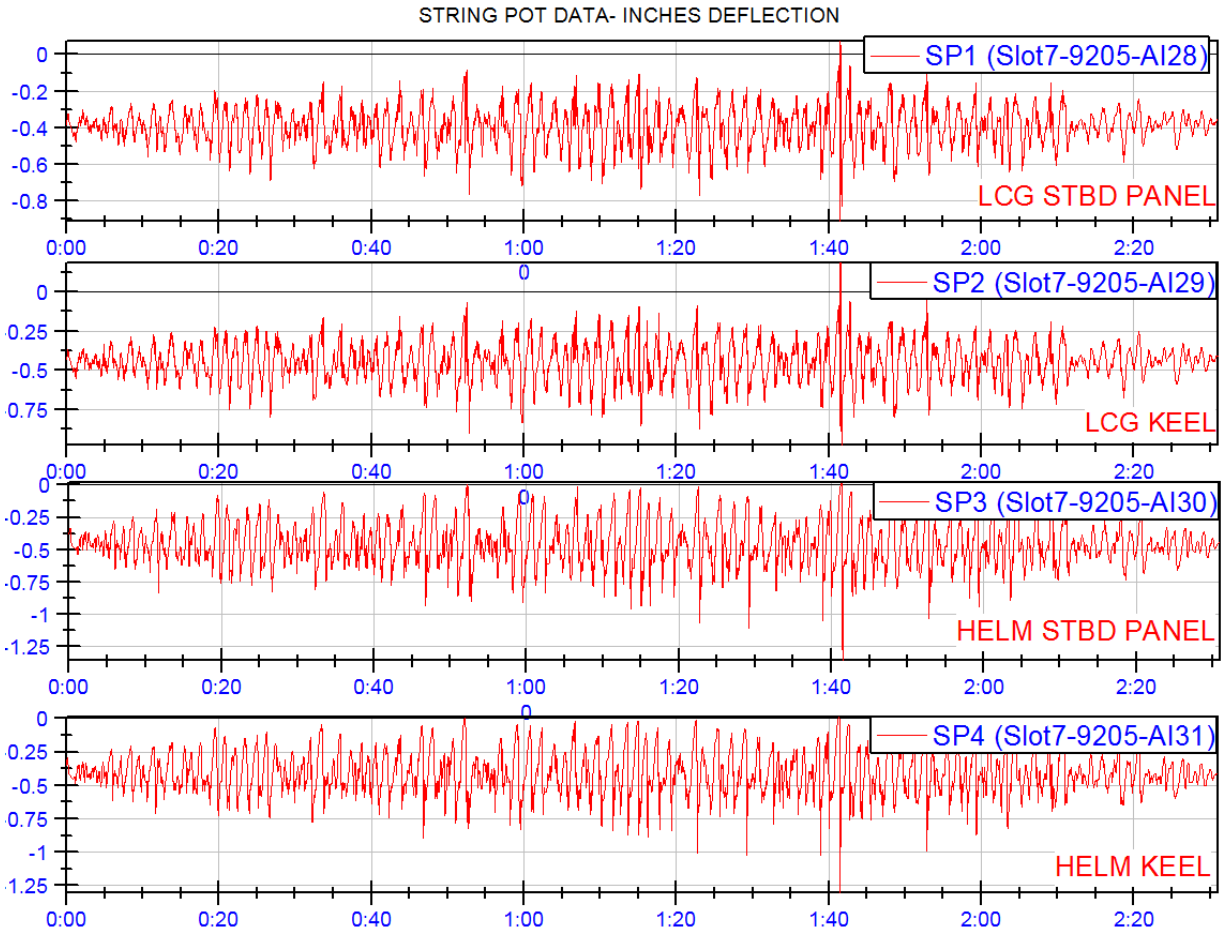


Figure 64 - Hull to Deck deflection Data (PC25 Sept - Ocean-Full Load)

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The figure below (figure 65) shows the internal hull pressure during the test run. The bow pressure transducer was not operational for this run. The hull to deck cavity was not actively pressured for this run so this plot represents the internal pressure that builds due to deflections from the wave impact event. Peak pressures are about 1 psi.

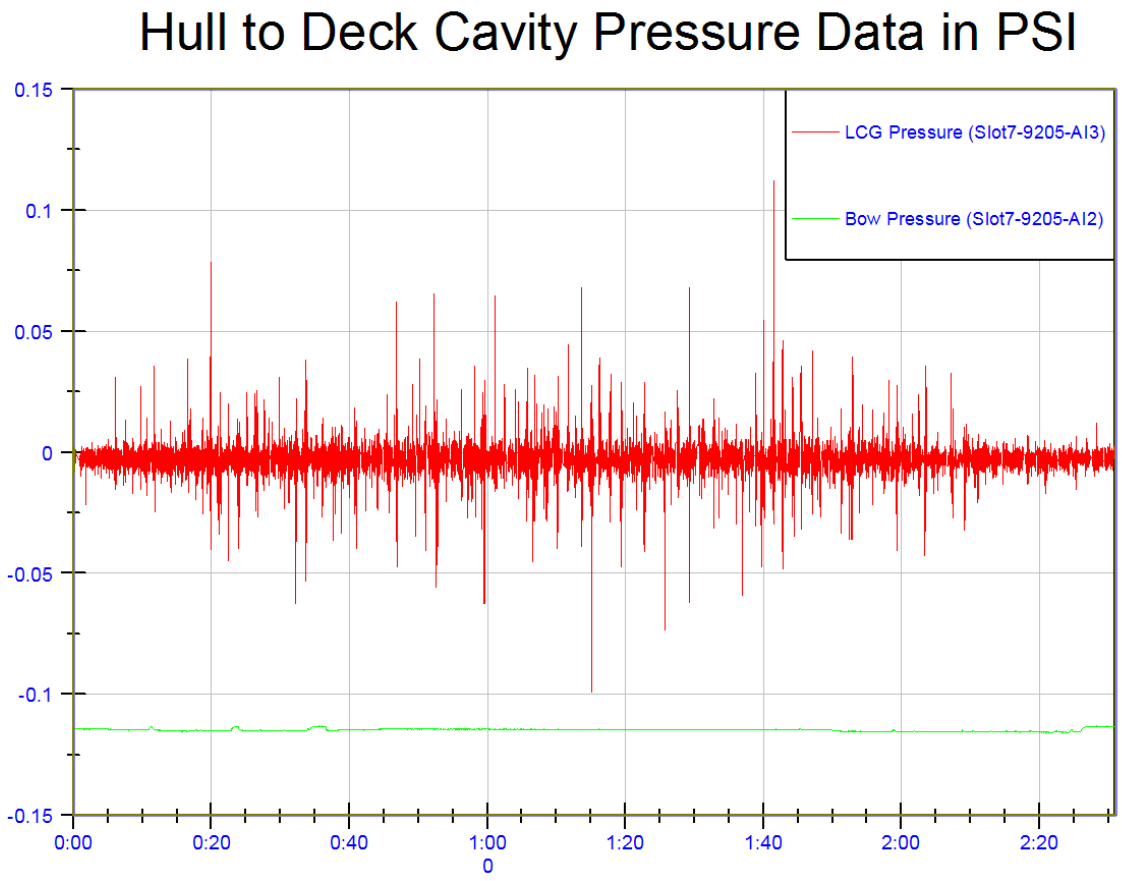


Figure 65 - air Pressure in the hull to Deck cavity during the run (PC25-Sept-Ocean-Full Load)

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Below (figures 66-68) are plots showing the strain data for the 25 September Ocean run under full load conditions. Three plots are shown; these are the hull strain gauges. Following those are plots showing the strain results on the transom and strain results for the strain gauges on the deck.

The following designations are used to help visualize location:

- LF=Strain Gauge on Longitudinal Frame
- TF= Strain Gauge on Transverse Frame
- P= Strain Gauge on Panel (0=fore-aft, 90=transverse, 45=45 degree angle)
- SF= Strain Gauge on side of Prisma^{TM} Beam (Frame)

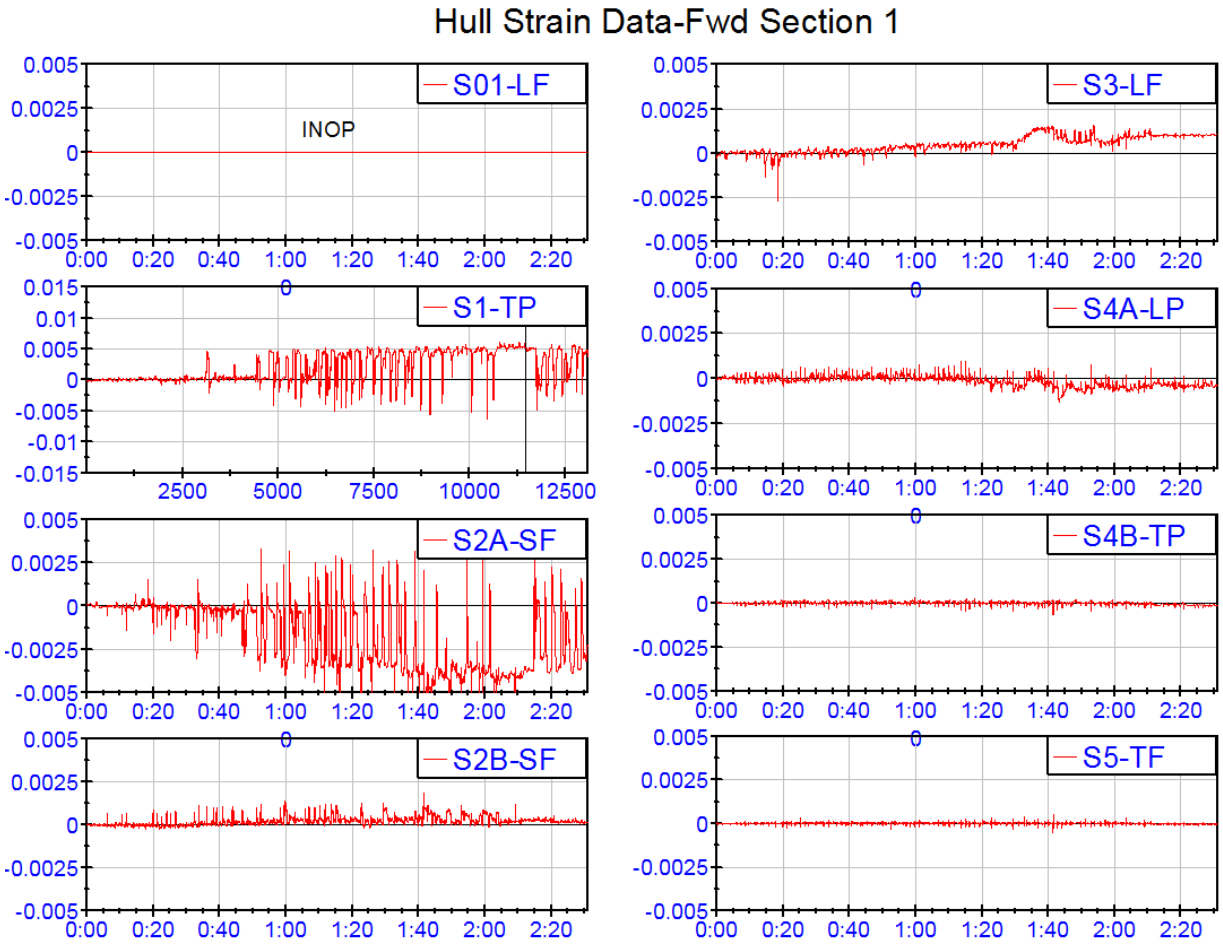


Figure 66 - Hull Strain Data during the run (PC 25 Sept-Ocean-Full Load)

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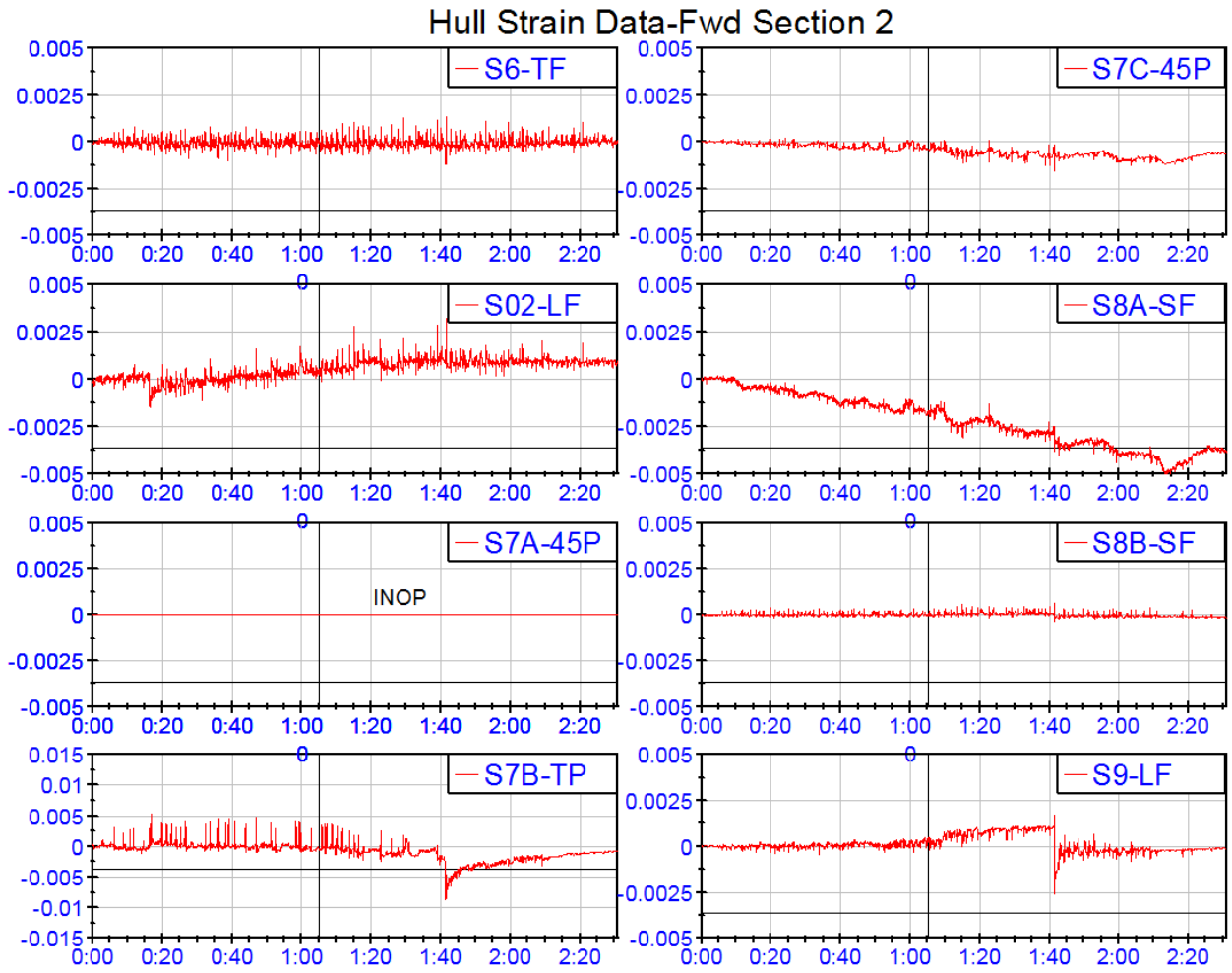


Figure 67 - Hull Strain Data during the run (PC25 Sept-Ocean-Full Load)

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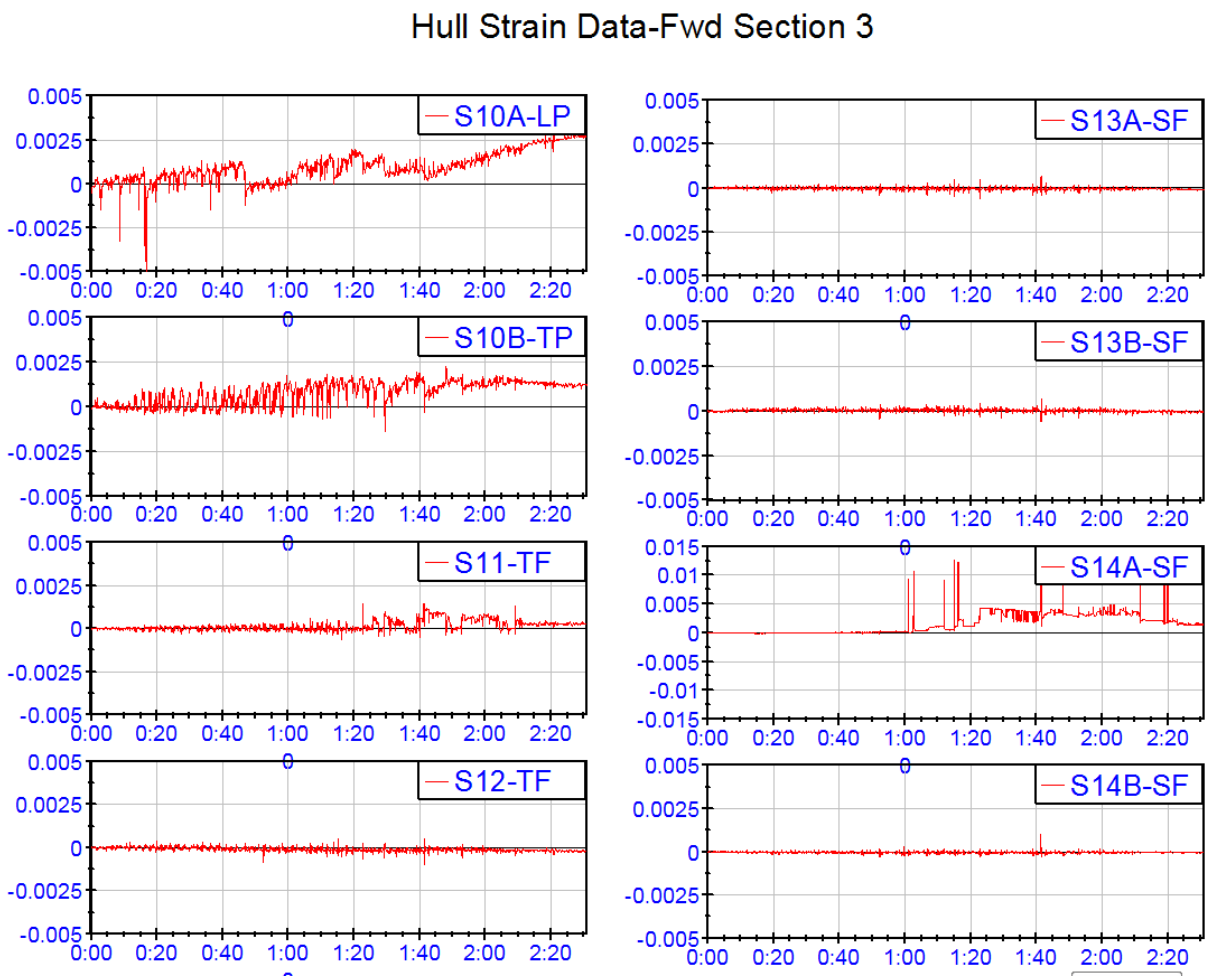


Figure 68 - Hull Strain Data during the run (PC 25 Sept-Ocean-Full Load)

The hull strain data indicates that overall strain levels are within acceptable limits. The highest strains on the hull were observed at S14A which is on the side wall of one of the aft transverse frames. S14B which is perpendicular to S14A did not show as high a strain level. Strains for S14B slightly exceeded 1%. Some drift perhaps due to electronics is seen in some of the data.

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The following plot (figure 69) shows the strains measured on the two transom mounted strain gauges. The measured strains were very low with peak strain of 0.1%.

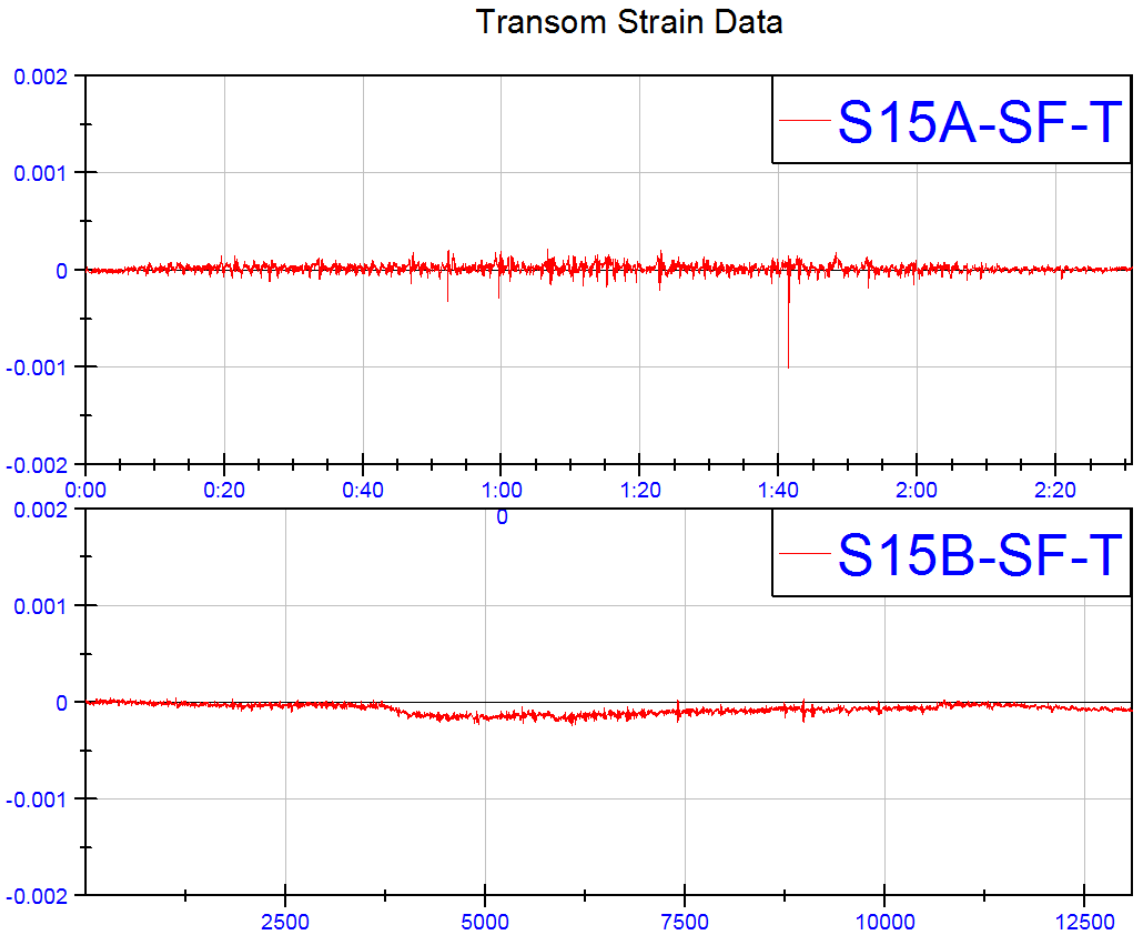


Figure 69 - Strain Data for the Transom (PC 25 Sept-Ocean-Full Load)

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The plots below (figure 70) show the strain levels measured on the deck of the 850B. Strain levels were generally low with maximum strains of 0.4% which were observed on S18 gauge mounted on a transverse deck frame just forward of the deck hatch.

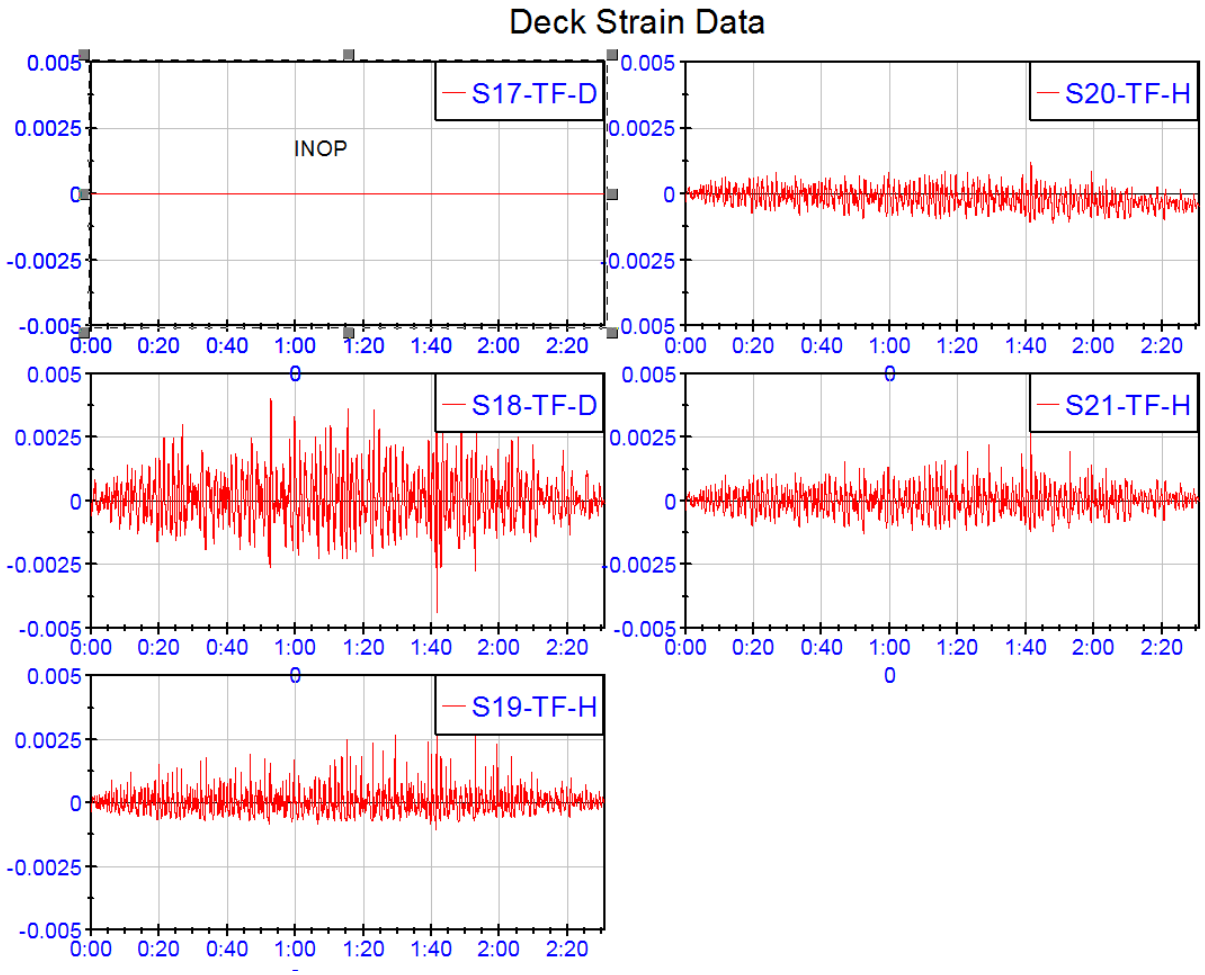


Figure 70 - Deck Strain Measurements (PC 25 Sept-Ocean-Full Load)

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The following plots show the strain data for the large slam event. The first figure 71 below shows the hull frame cap strains during the slam event. The second figure 72 shows the strains for the hull panels, and the third figure 73 shows the strains for the hull frame sidewalls.

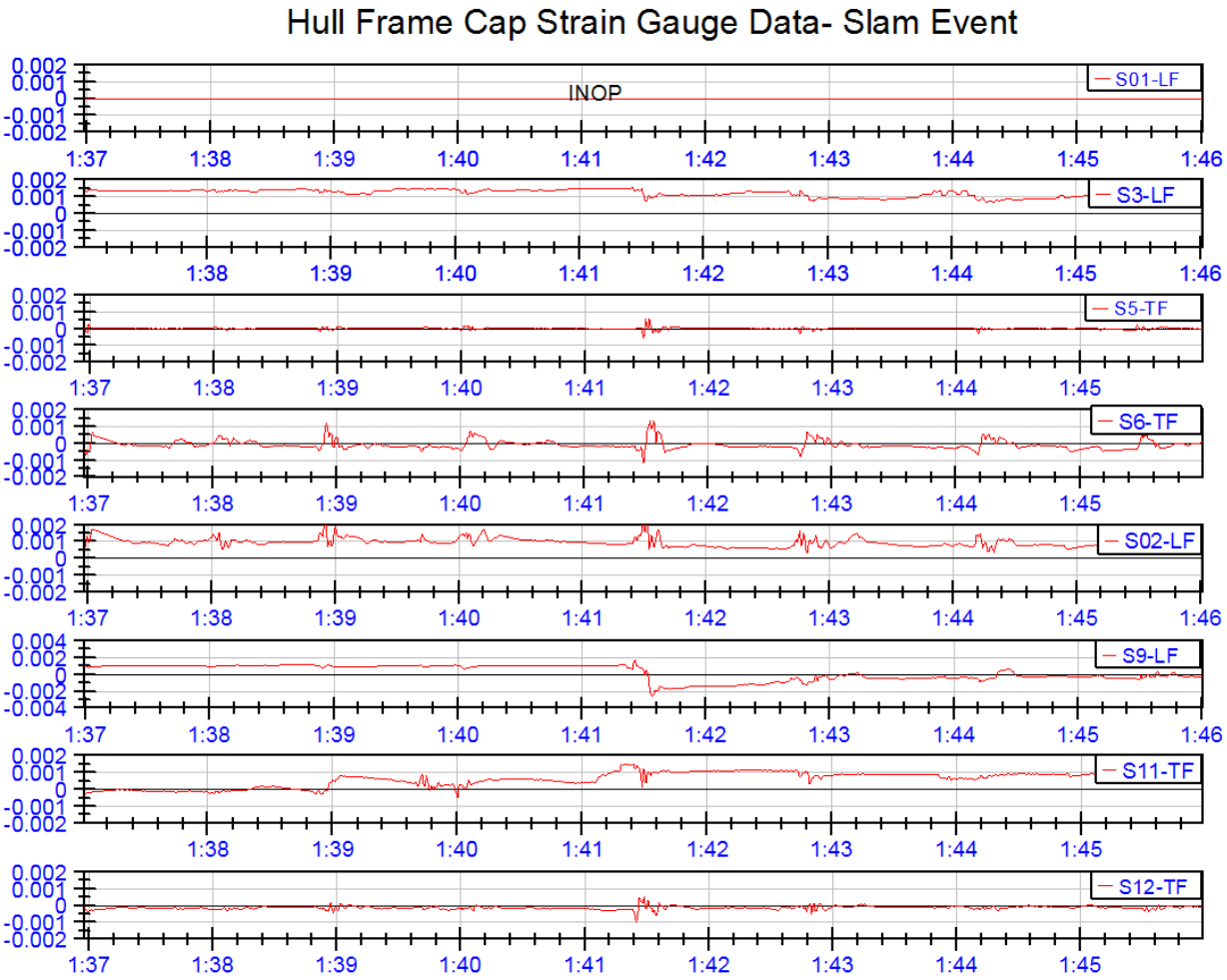


Figure 71 - Strain Data for the Hull Frame Caps (PC25 Sept-Ocean-Full Load)

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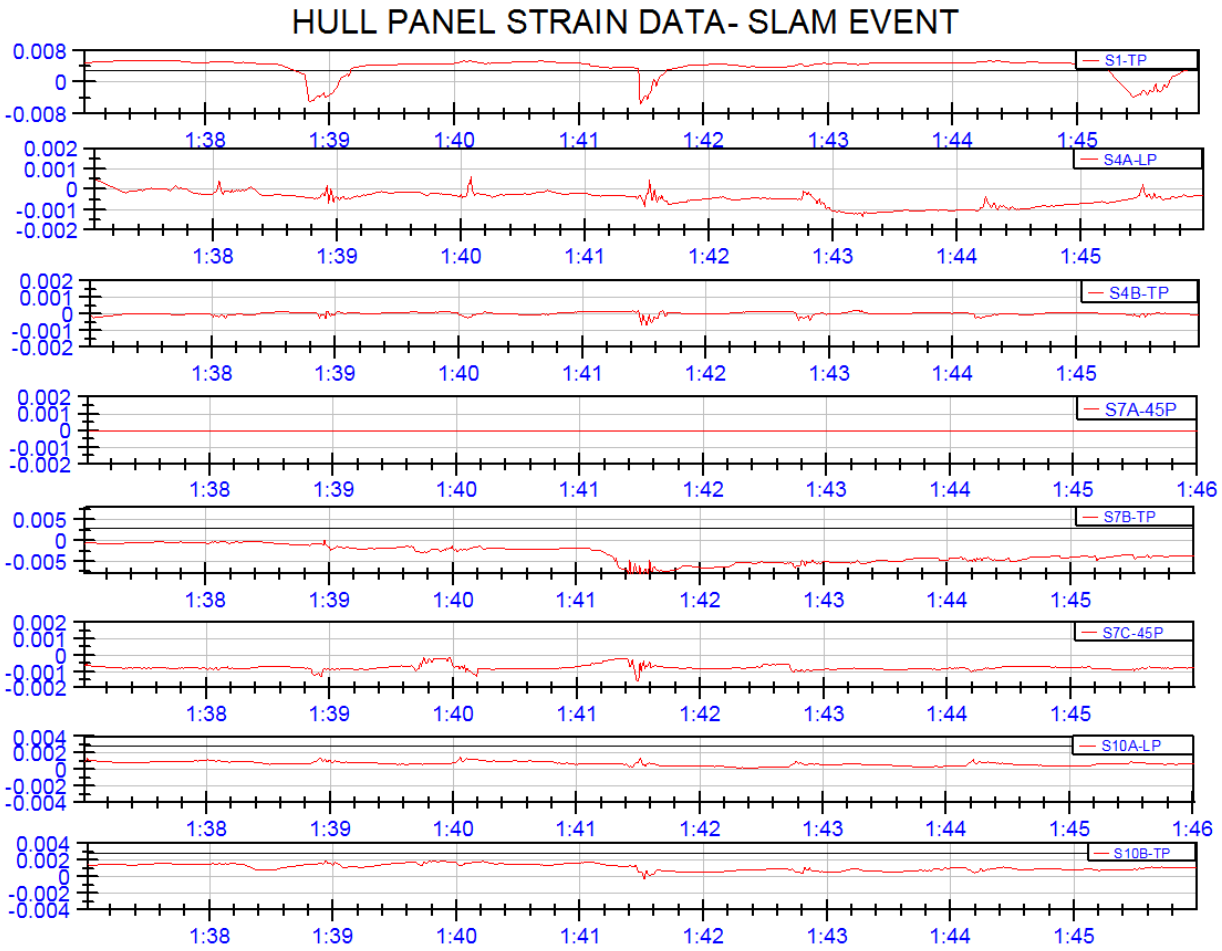


Figure 72 - Strain data for the Hull Panels (PC25 Sept-Ocean-Full Load)

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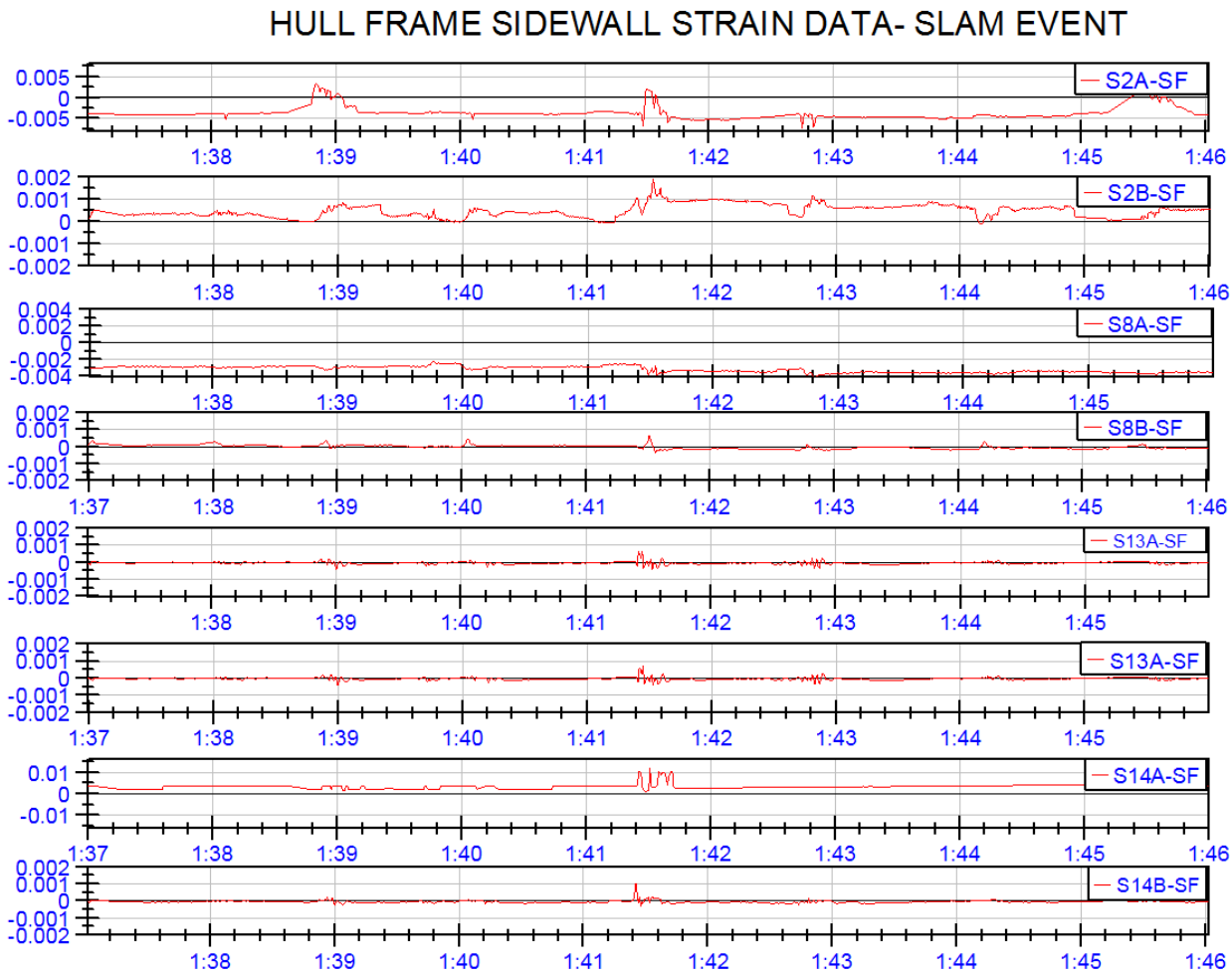


Figure 73 - Strain data for the Hull Frame Sidewalls (PC25 Sept-Ocean-Full Load)

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The figure below (figure 74) shows the strain data for the deck during the slam event.

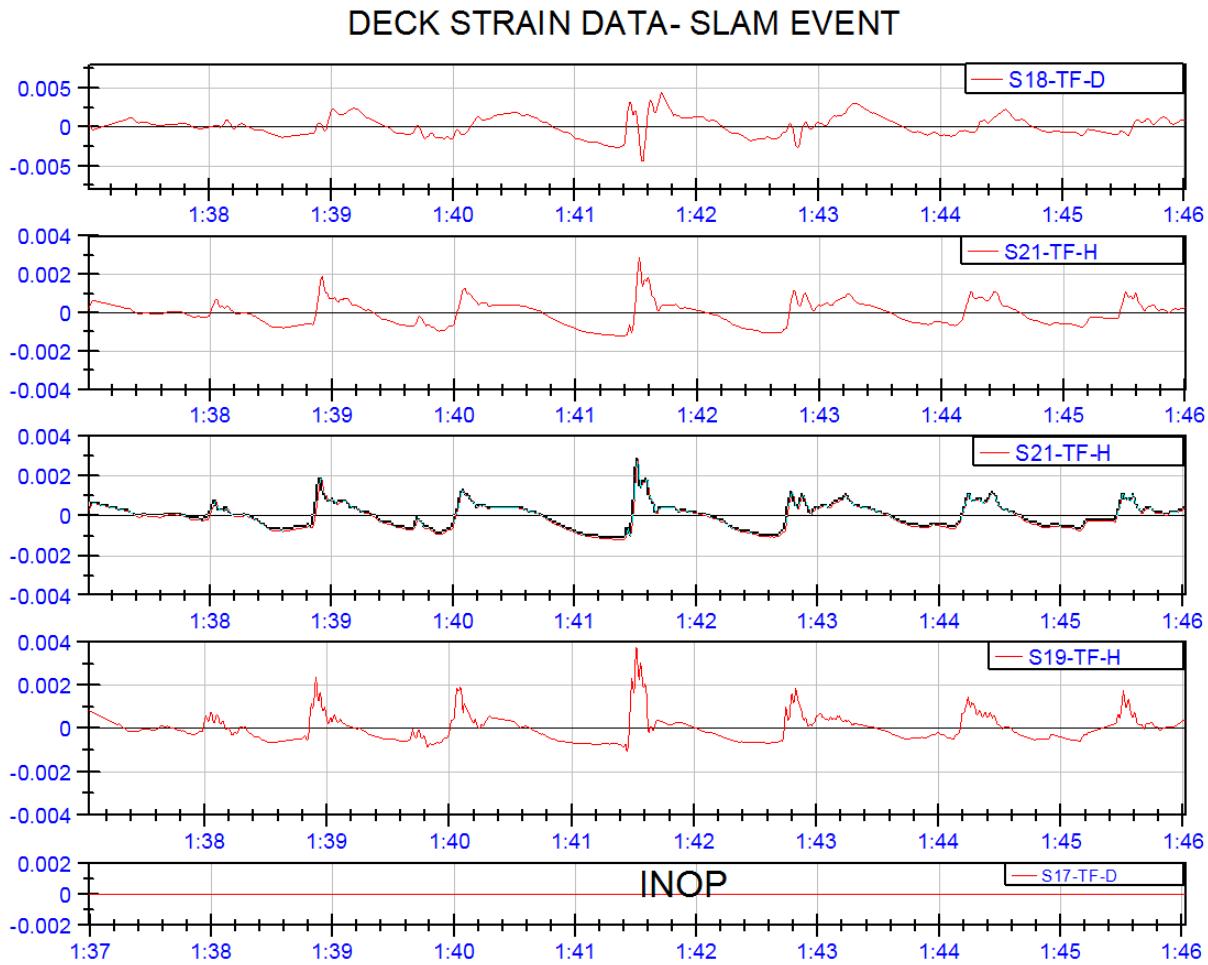


Figure 74 - Strain Data for the Deck (PC25 Sept-Ocean-Full Load)

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The following plot figure 75 shows the strain data for the transom during the slam event.

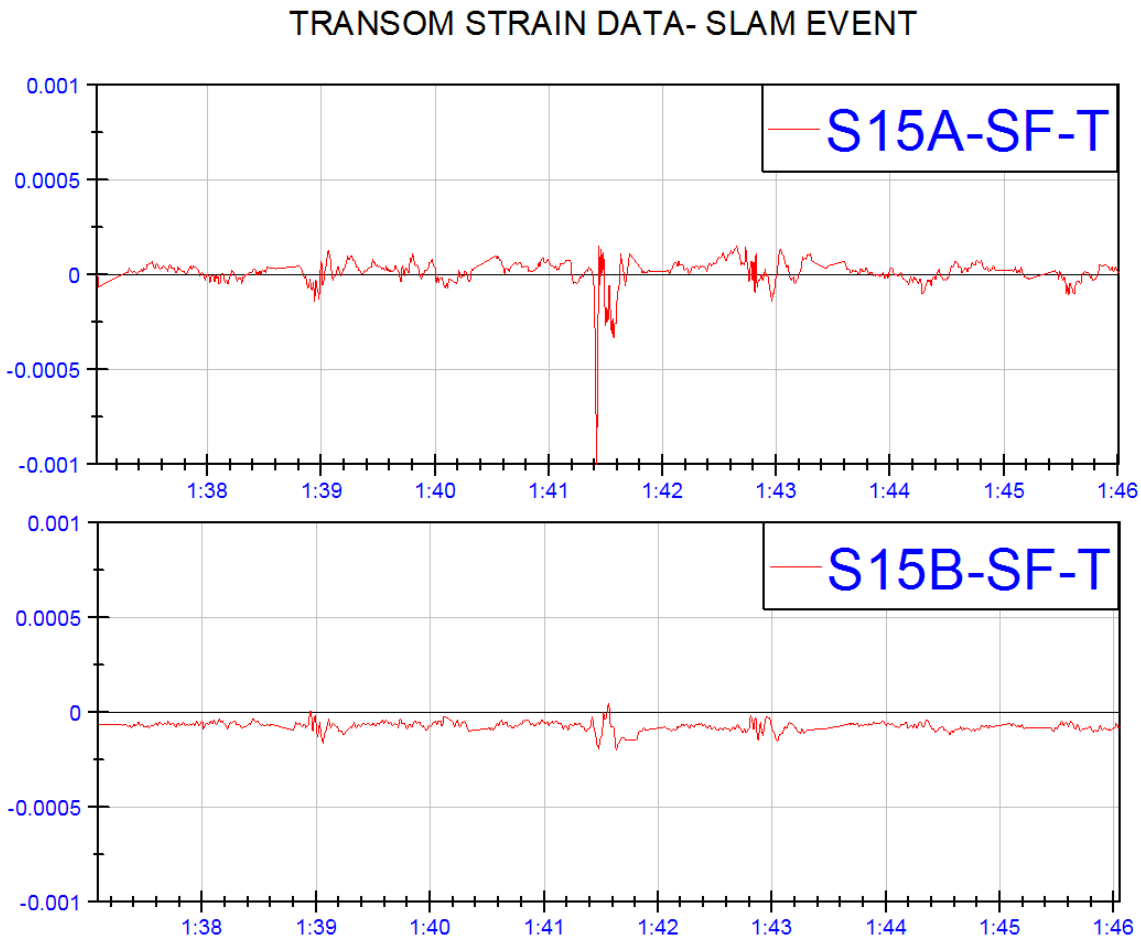


Figure 75 - Strain Data for the Transom (PC25 Sept-Ocean-Full Load)

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The following plot figure 76 shows hull strain, deck strain and string pot data for the slam event.

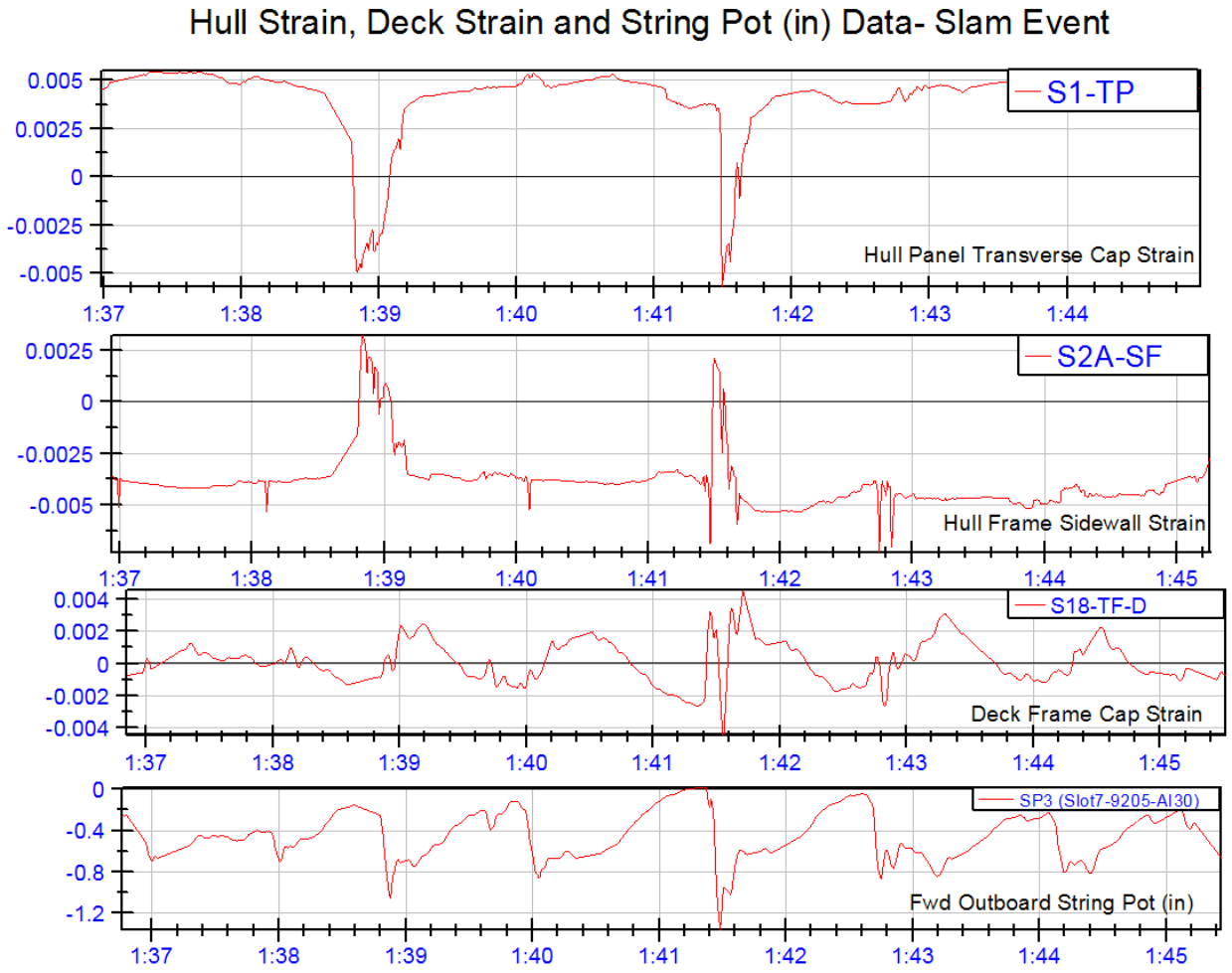


Figure 76 - Strain Data for Selected Strain Gauges and the Fwd Outboard String Pot (PC25 Sept-Ocean-Full Load)

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The following plot (figure 77) shows vertical acceleration data for LCG at the hull and deck locations along with String Pot #2 which is located between the keel and deck at LCG. Note that the hull panel appears to have a higher frequency response to the slam event when compared to the deck. Also note that the string pot data appears to have an even lower frequency response; this may be due to the limitations of the mechanical string pot device.

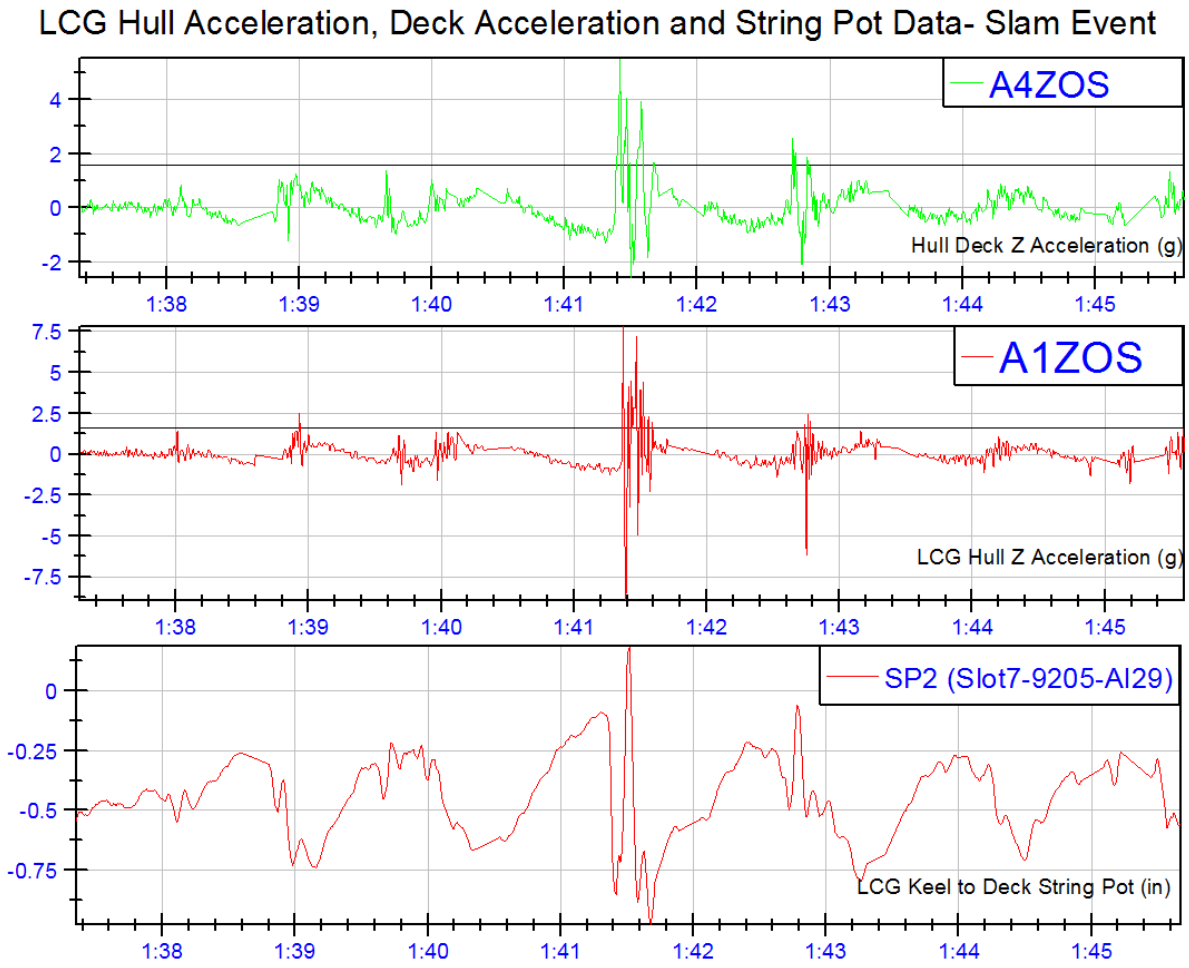


Figure 77 - Vertical Acceleration Data at LCG and LCG String Pot data (PC25 Sept-Ocean-Full Load)

In summary, this run shows some very interesting aspects of the craft. The data supports significant decoupling of the hull and deck. String pot data indicates that we have created a structure that is not a rigid body which is the standard assumption for small craft. Wave impact response data indicates that the hull and deck reverberate independently, and the natural frequencies for the hull and deck are different from one another. Strain data indicates that we are within acceptable strain limits for the material.

Numerous runs were made in the fully loaded condition. The runs made offshore Port Canaveral Florida on November 13th had some of the most severe operational conditions. Wave heights

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were 4+ ft at the wave data station, the reported wave heights were 4 to 6 ft. The data collected had a few issues, these included the hull mounted accelerometers giving suspect data and the sampling rate reduced to 66 Hz. The accelerometer issue appears to be due to the gauges being affected by prior submergence. The strain data did show some higher strains than were observed on the above run.

The following figure 78 is a data set from Run 3 Port Canaveral 13 November running into the bow at speeds of 30-35 MPH.

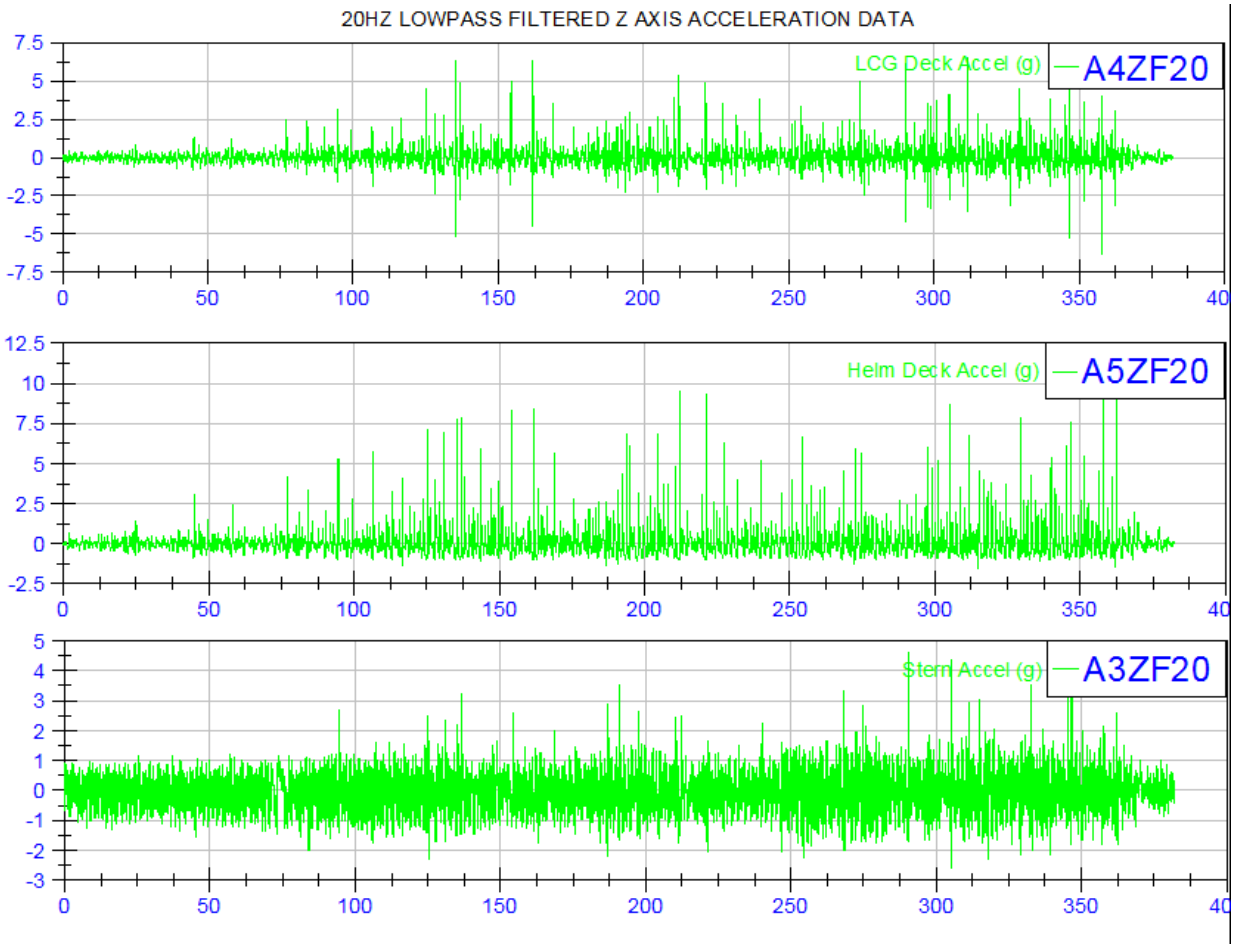


Figure 78 - Deck and Stern Z axis Acceleration data after low pas 20 Hz filtering (PC11-13 Run 3)

Deck accelerations shown above have been filtered with a low pass 20 Hz butterworth filter. Note the higher accelerations due to the large wave conditions. Hull and bow accelerometer data were suspect and are not included.

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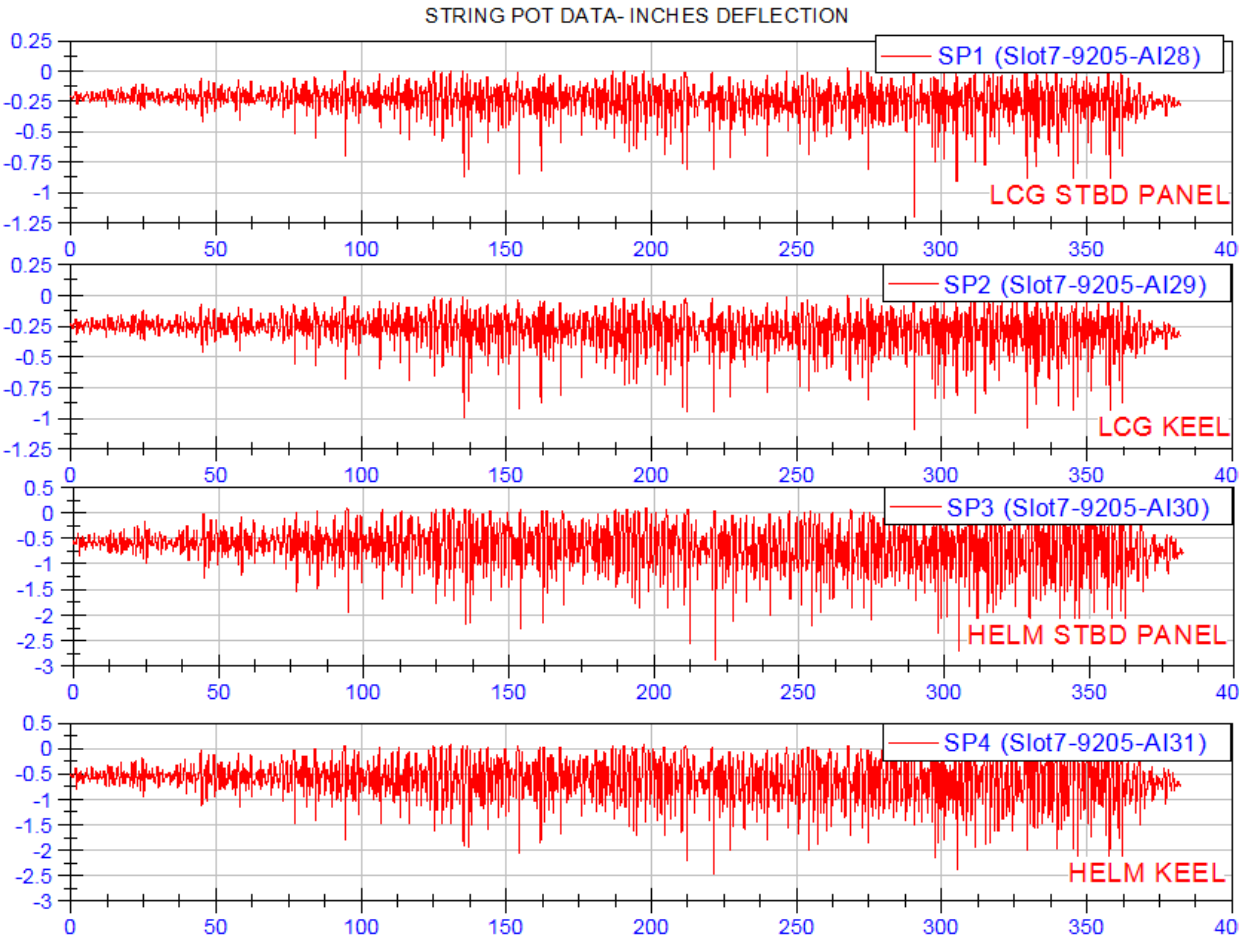


Figure 79 - String Pot data in inches (PC11-13 Run 3)

String pot data for this run shown in figure 79 above shows larger hull to deck deflections. Peak deflections due to the combination of deck load and slamming load for this run were 2.5 inches at the helm station and 1.2 inches at LCG.

The following figures 80-84 are the time series on the strain gauges for this run.

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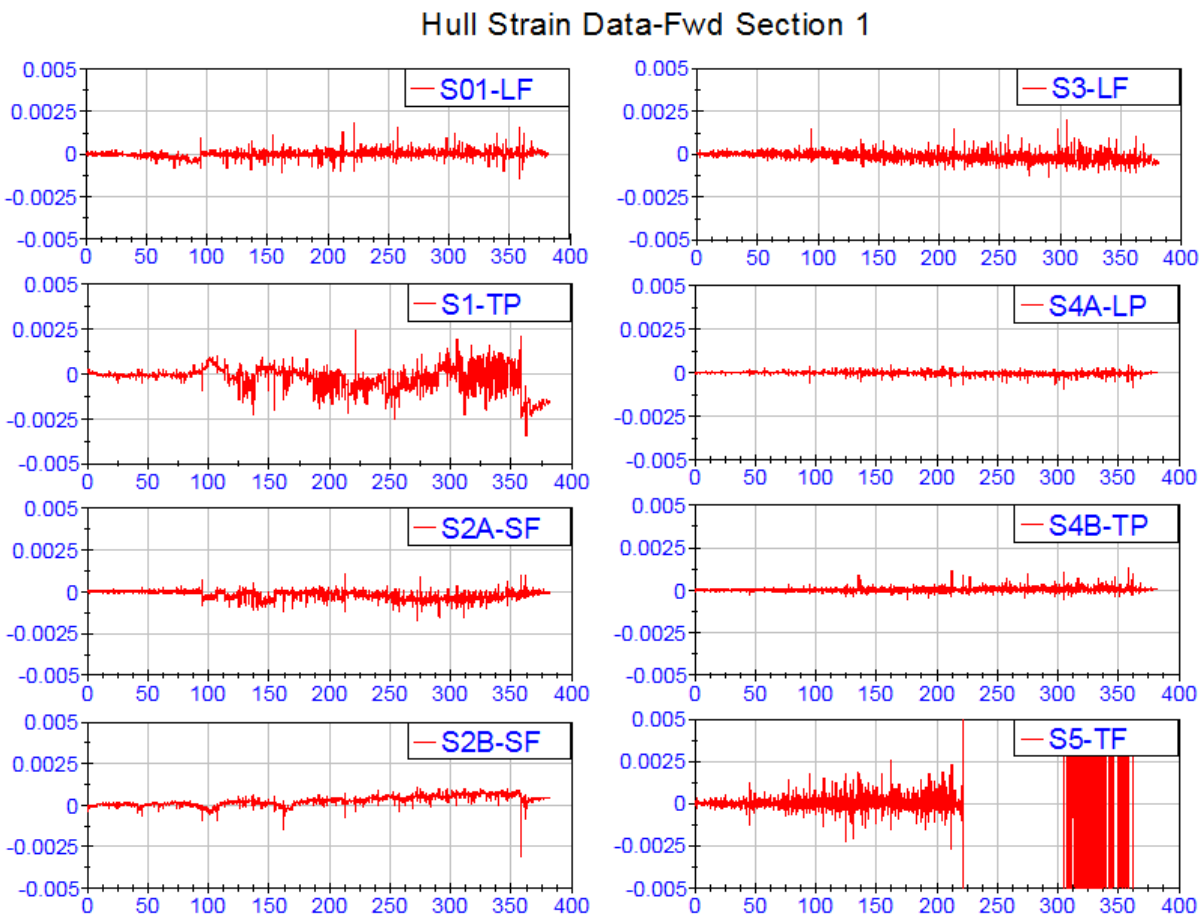


Figure 80 - Forward section strain data for PC11-13 Run 3 Gauges 1-5

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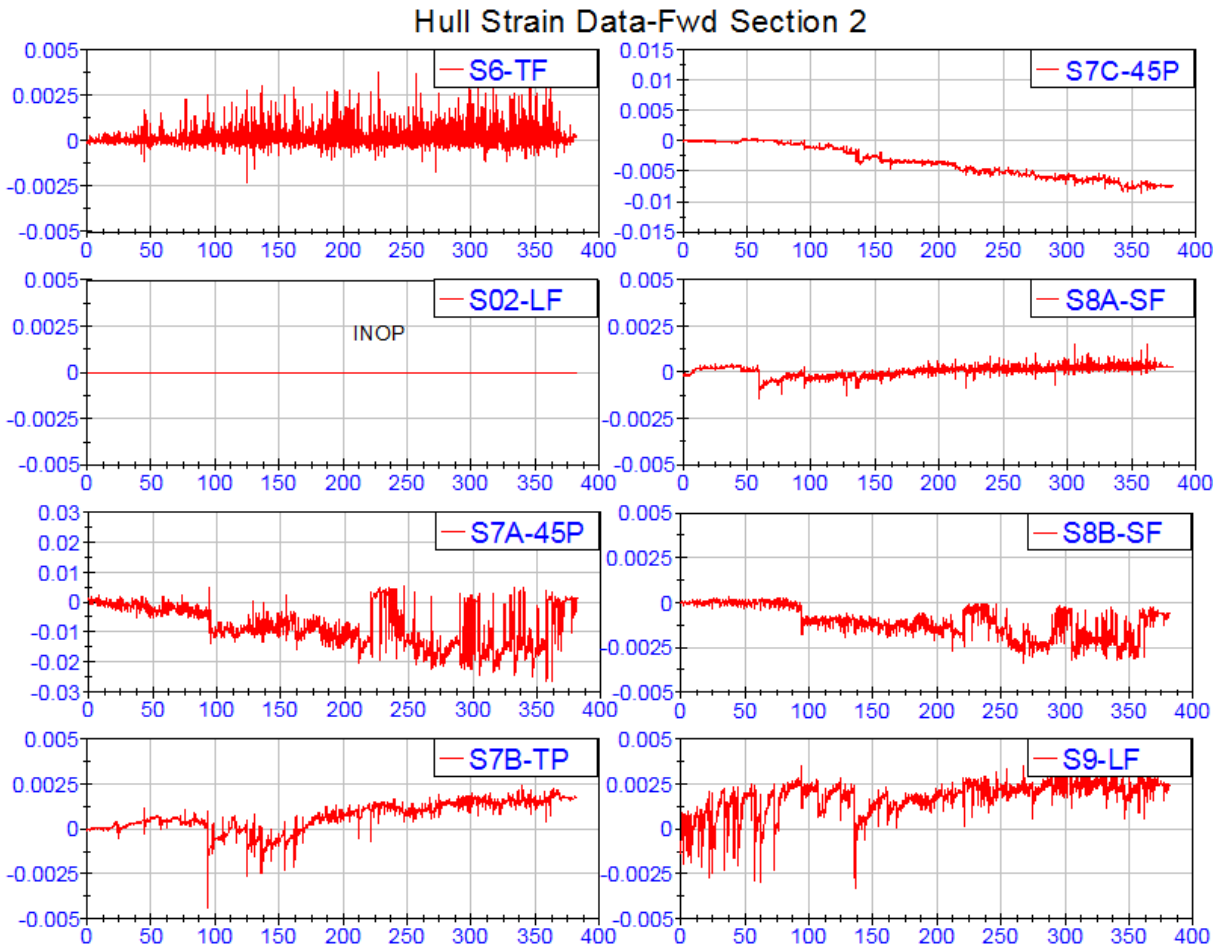


Figure 81 - Strain data for PC11-13 Run 3 Gauges 6-9

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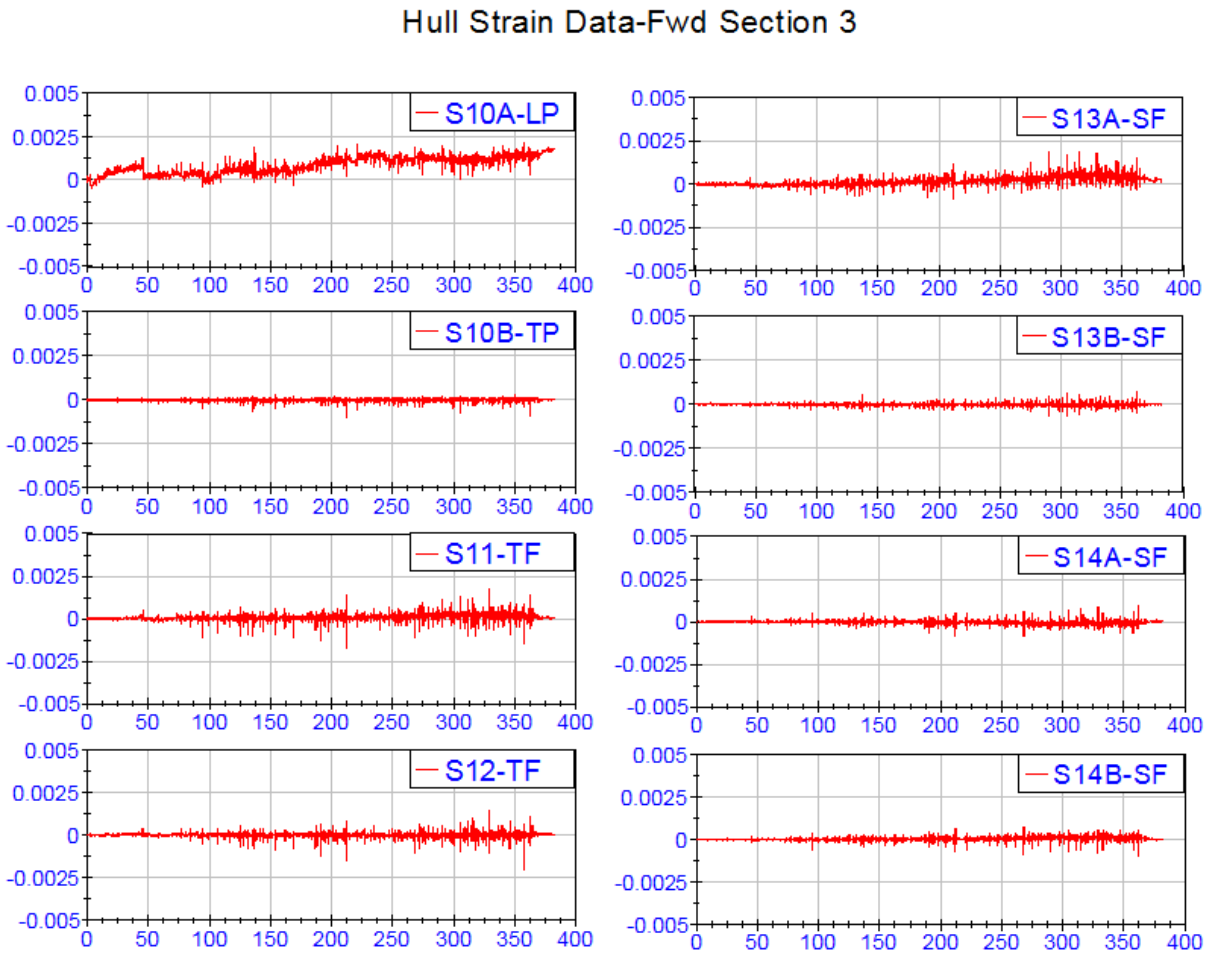


Figure 82 - Strain Data for PC11-13 Run 3 Gauges 10-14

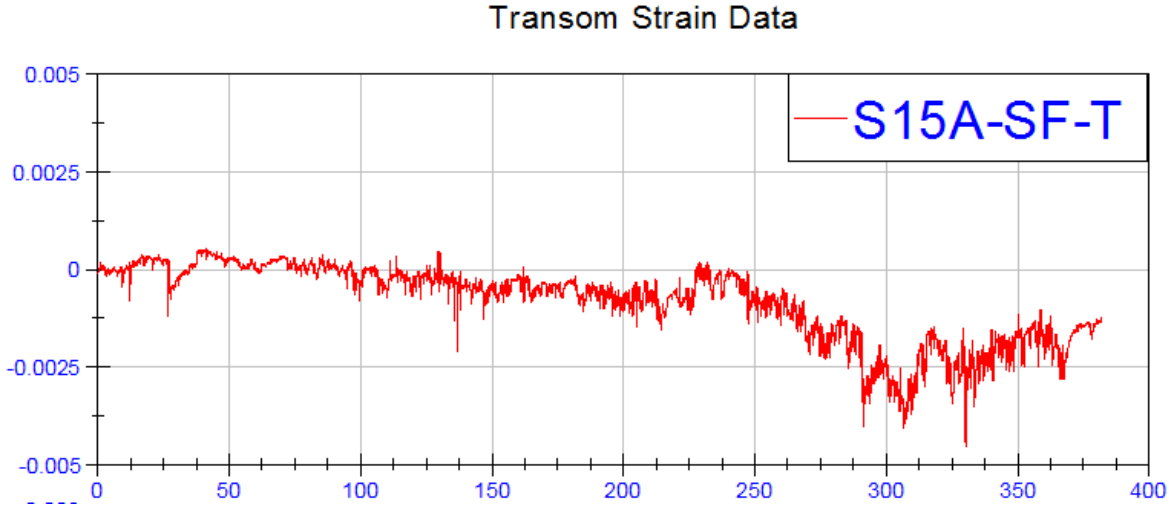


Figure 83 - Strain data for PC11-13 Run 3 Transom Gauge

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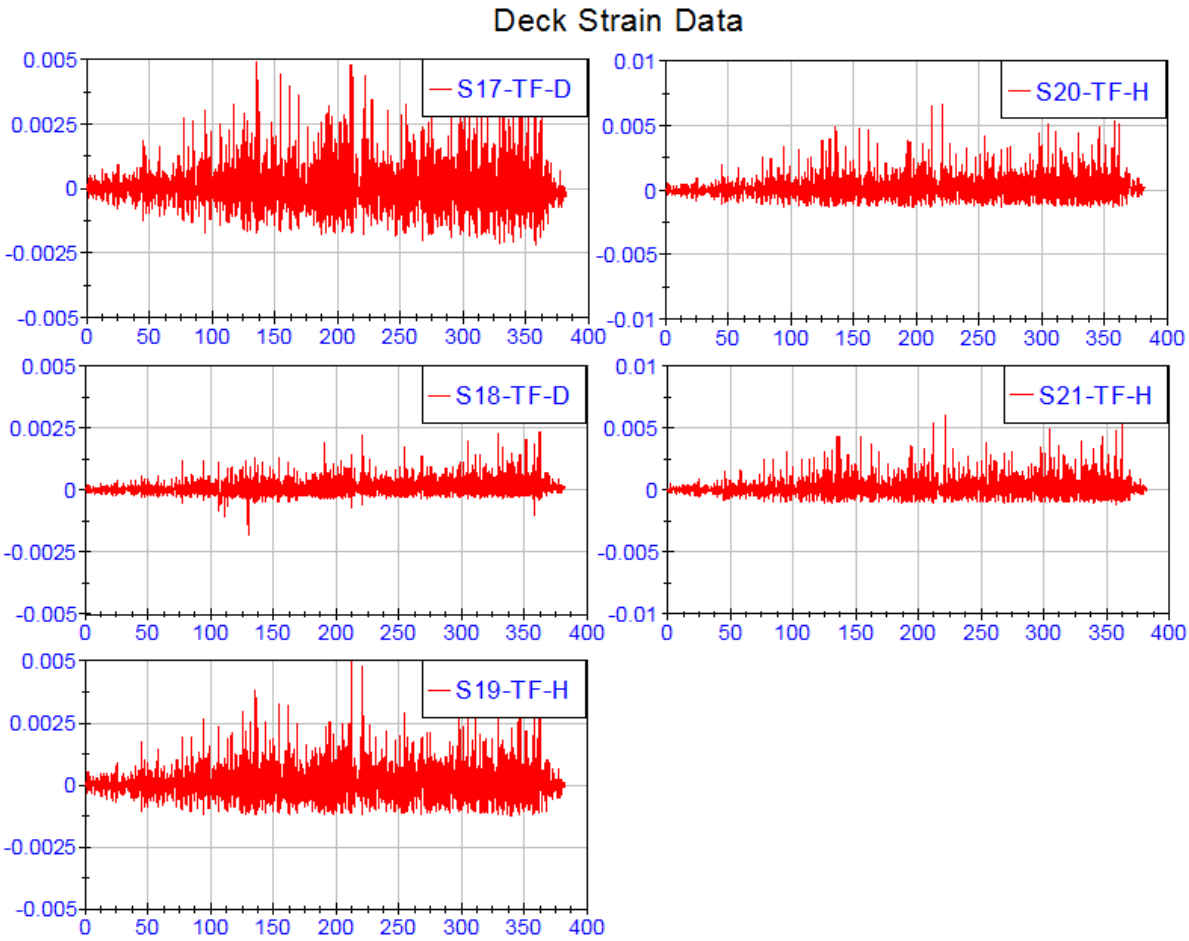


Figure 84 - Strain Data for PC11-13 Run 3 Deck Strain Gauges

Strain gauge S7A-45P is showing high strain rates (over 2%). This strain gauge is located on one of the forward panels at 45 degrees. Strain gauge S7C-45P which is perpendicular to gauge S7A-45P showed some drift with a maximum strain of 1%. After this run it was noted that the hatch was sagging and some fasteners were damaged. Upon further inspection it was determined that the longitudinal frame of the hatch was impacting the transverse frame near this strain gauge. This localized damage was repaired when the hatch and deck were reworked to remove the sag and improve the hatch to deck connection. The hull area near these gauges did not show signs of damage.

Damage was observed at the hatch to hull interface; even with this damage the strain levels on the deck framing are within reasonable limits. The rework of the deck and hatch flange is expected to resolve the issue. Other strains are within reasonable levels. In particular the transom strain is low.

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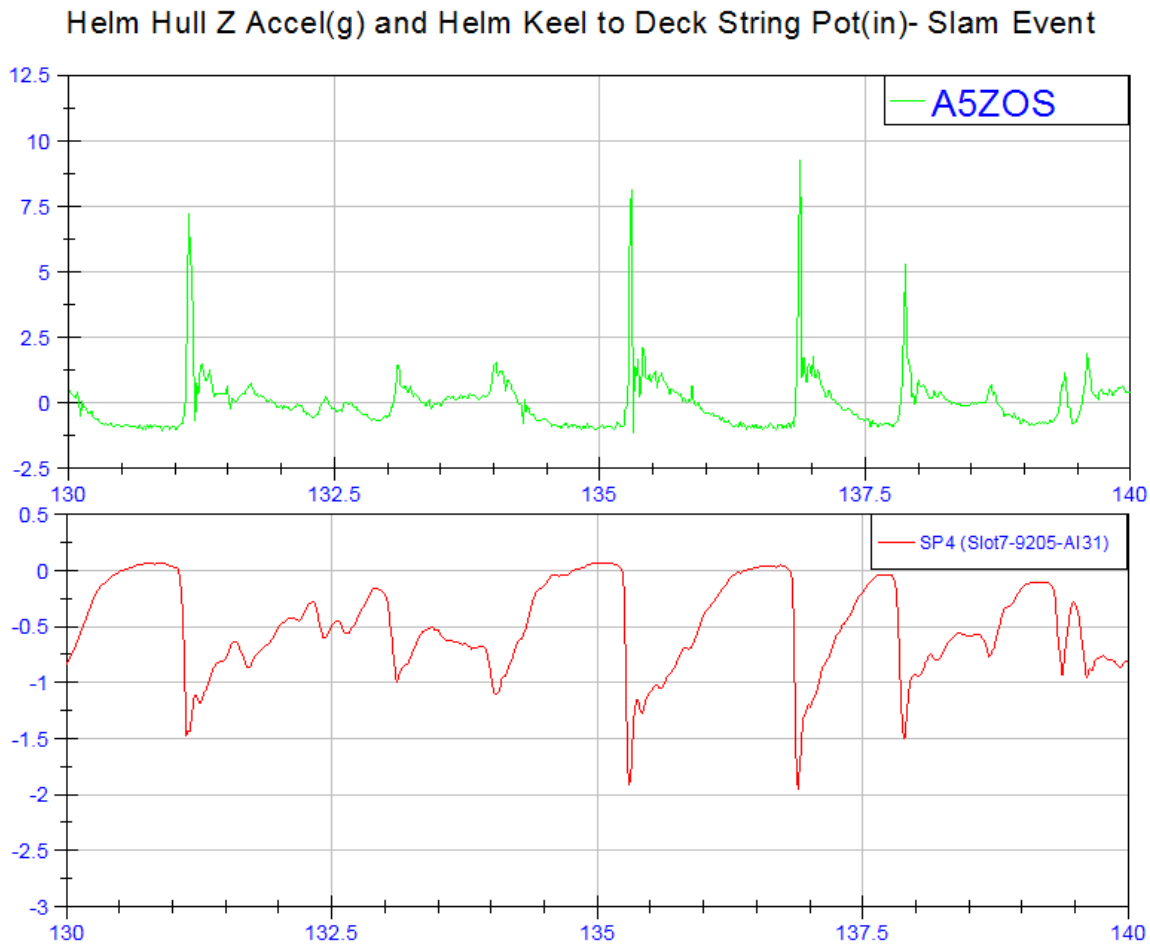


Figure 85 - Helm Z Acceleration and Helm Keel to Deck String Pot data during slam event PC11-8 Run 3

The figure above shows the helm station deck mounted accelerometer and the associated string pot that measures deflection between the deck and hull at the helm station. The results show good correlation.

Appendix J presents all of the ocean data for both full load and light load conditions.

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5.4.3.5 850B Structural Performance - River Runs

The 850B was evaluated in the Indian River and at Sebastian Inlet, FL in the hoist and fully loaded conditions. Runs were made in light chop and runs were made over large boat wakes. Summaries of each of the runs are in Appendix K. The results of a run through Sebastian Inlet in the hoist condition are presented below, figures 86-87.

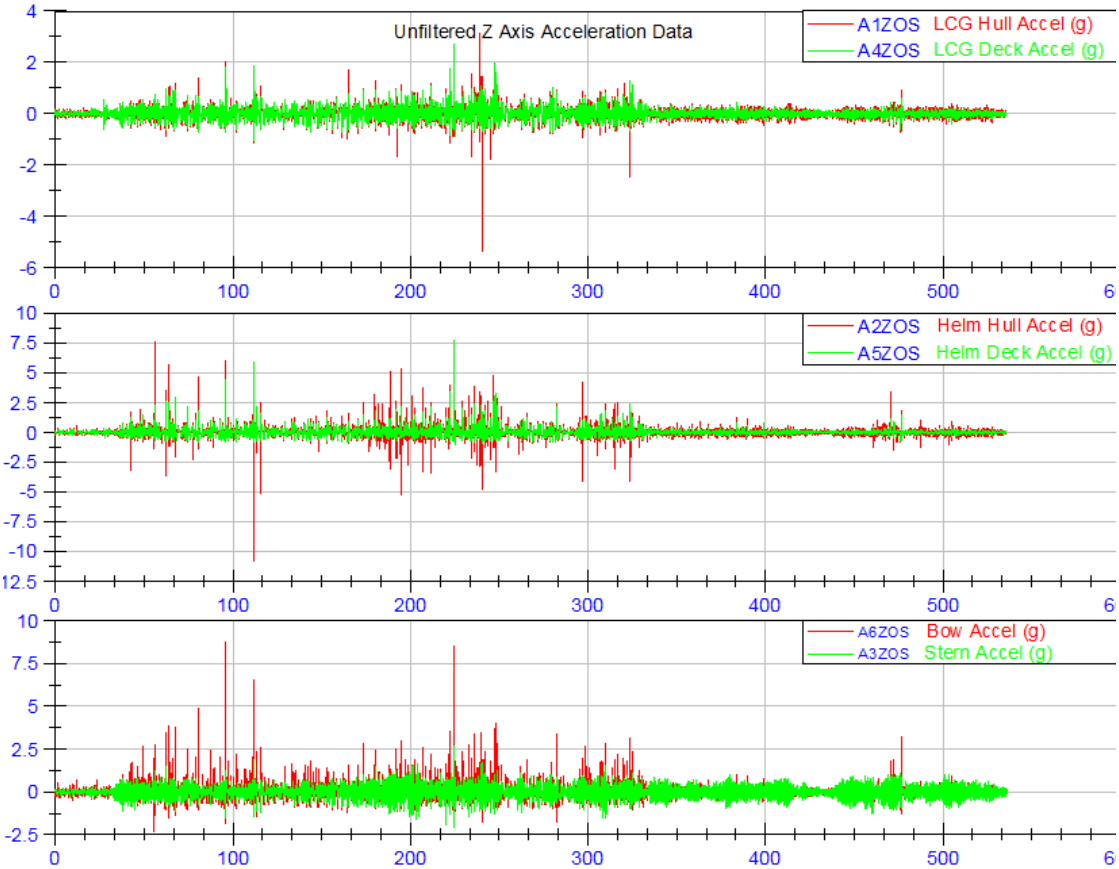


Figure 86 - Unfiltered Z axis Acceleration data Inlet Run 7-14-12

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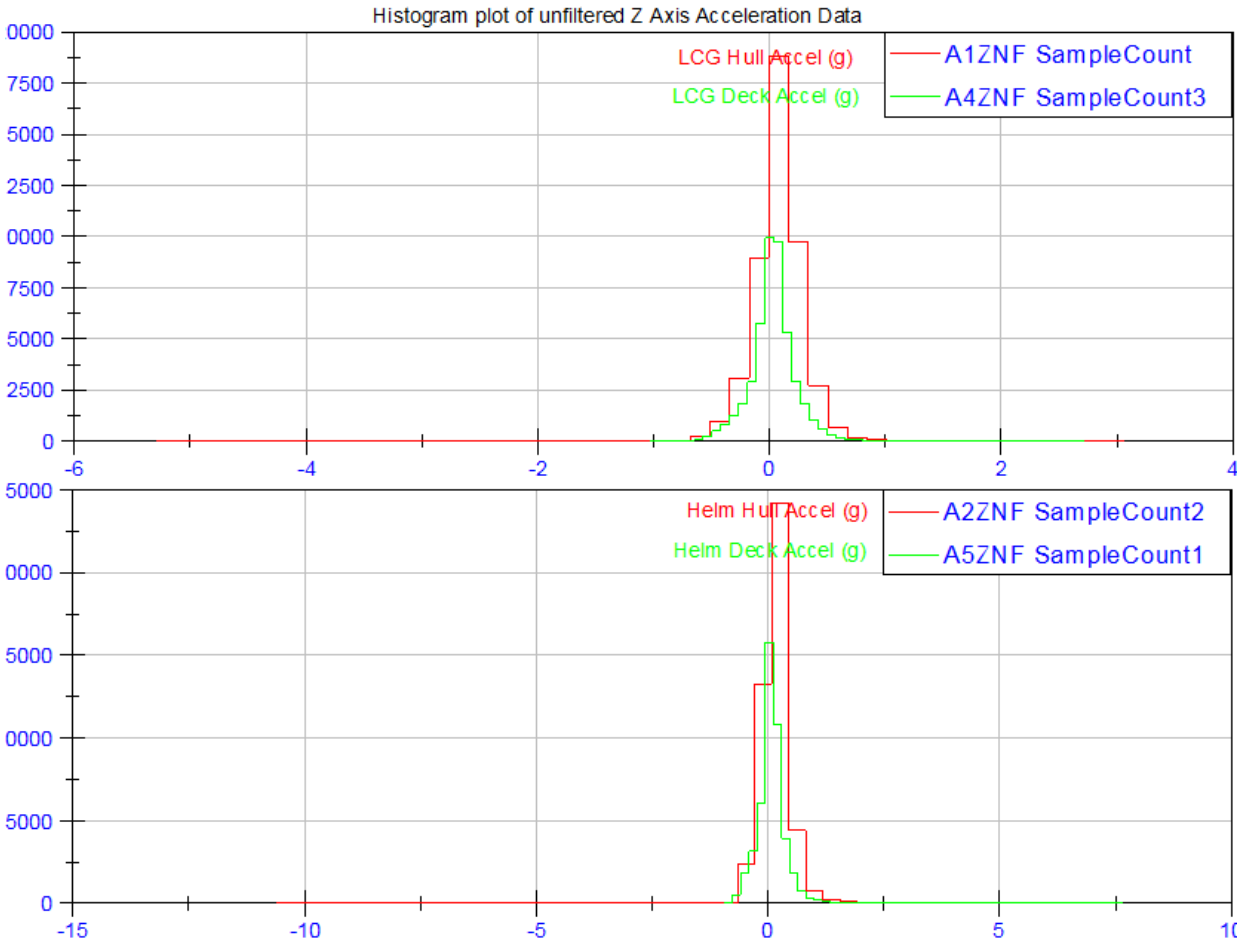


Figure 87 - Histogram plot of peak Z axis accelerations Inlet Run 7-14-12

Acceleration data for the boat in the hoist condition differs somewhat from that in the full load condition. The data supports the physical observation that the craft dampens shock better fully loaded. The helm station mounted to the forward hatch is noticeably more compliant when compared to the uninterrupted deck area at LCG. The data seems to indicate that the more compliant and weighted helm station reduces peak g load better than that observed at LCG.

The hull to deck deflection data presented below (figure 88) shows that deflections are reduced by approximately 50% when compared to the fully loaded condition in ocean operations.

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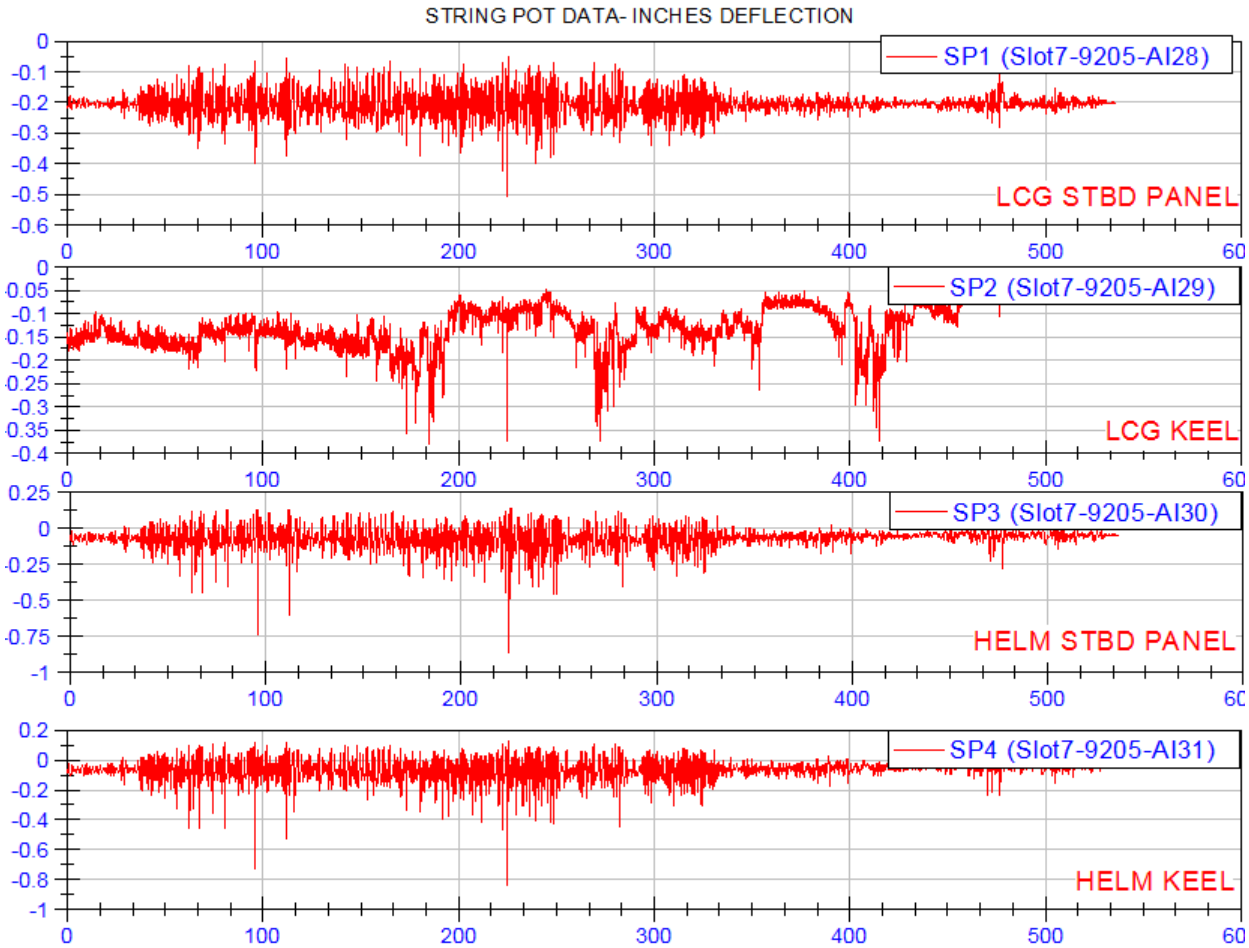


Figure 88 - Hull to deck deflection data in inches - Inlet Run 7-14-12

Below are the strain data for the Sebastian Inlet, FL run (figures 89-93). Note that strains are lower than those observed for runs in the full load condition. Some strain is data marked "suspect" which may be due to a loose connection.

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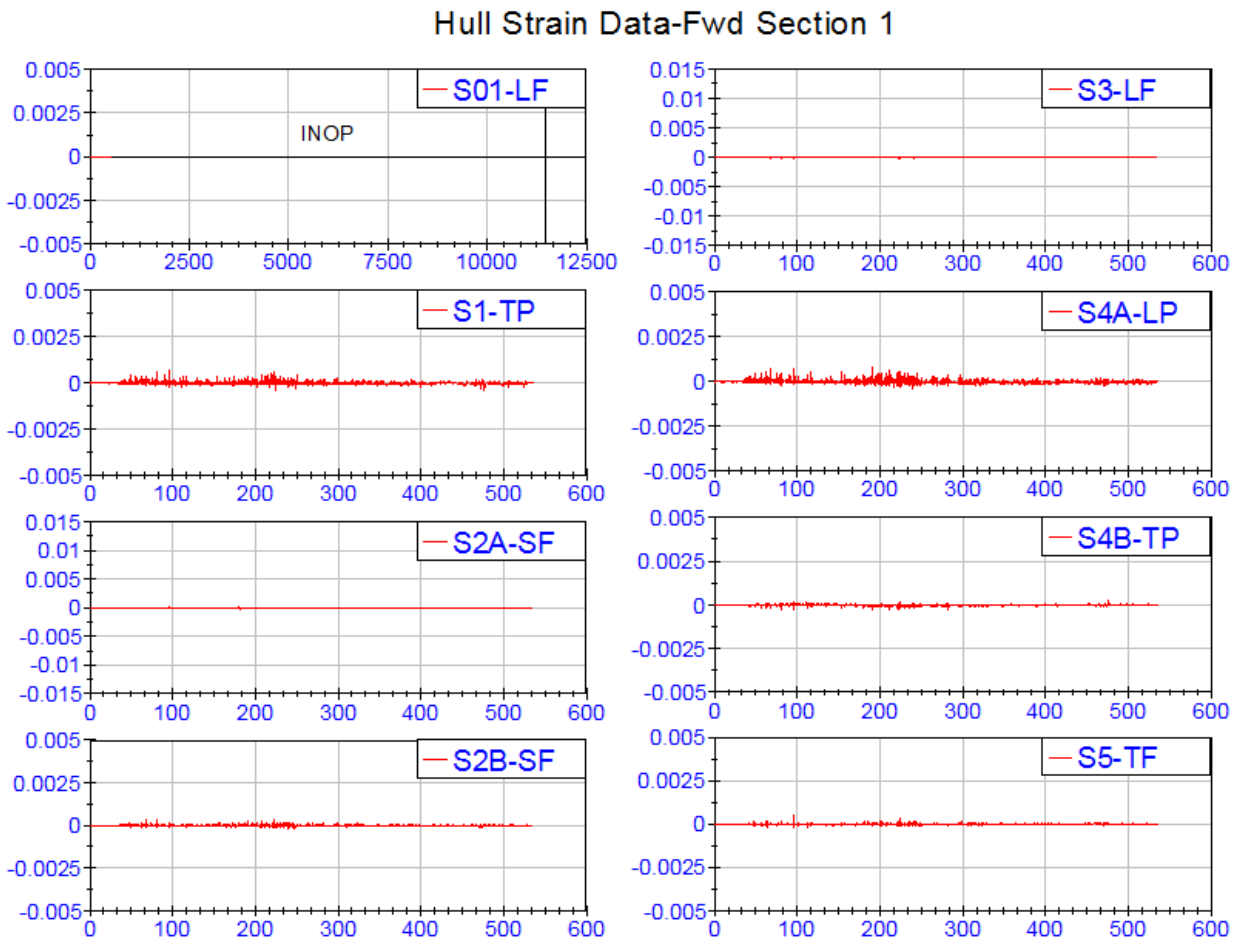


Figure 89 - Hull Strain data - Inlet Run 7-14-12

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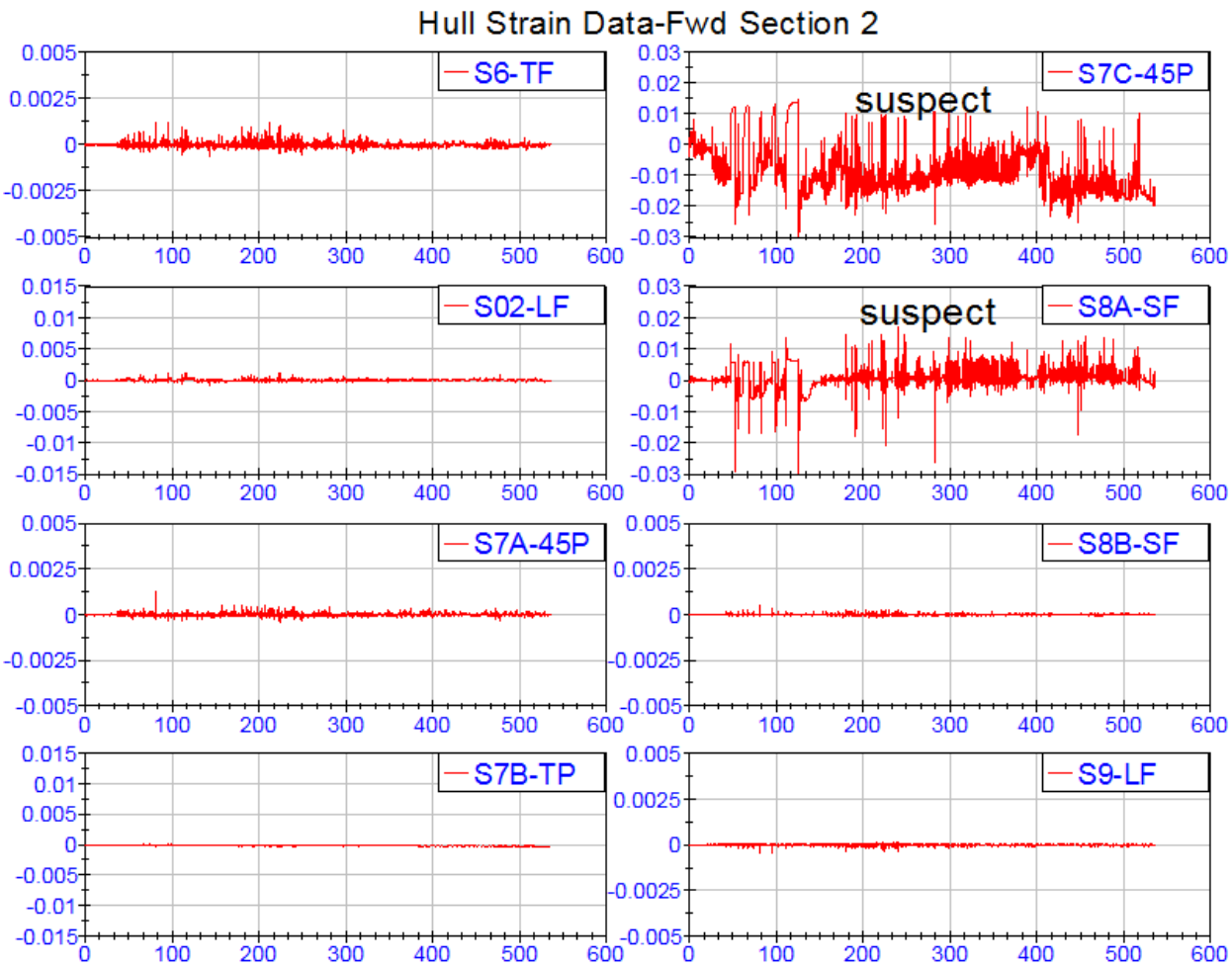


Figure 90 - Hull strain data - Inlet Run 7-14-12

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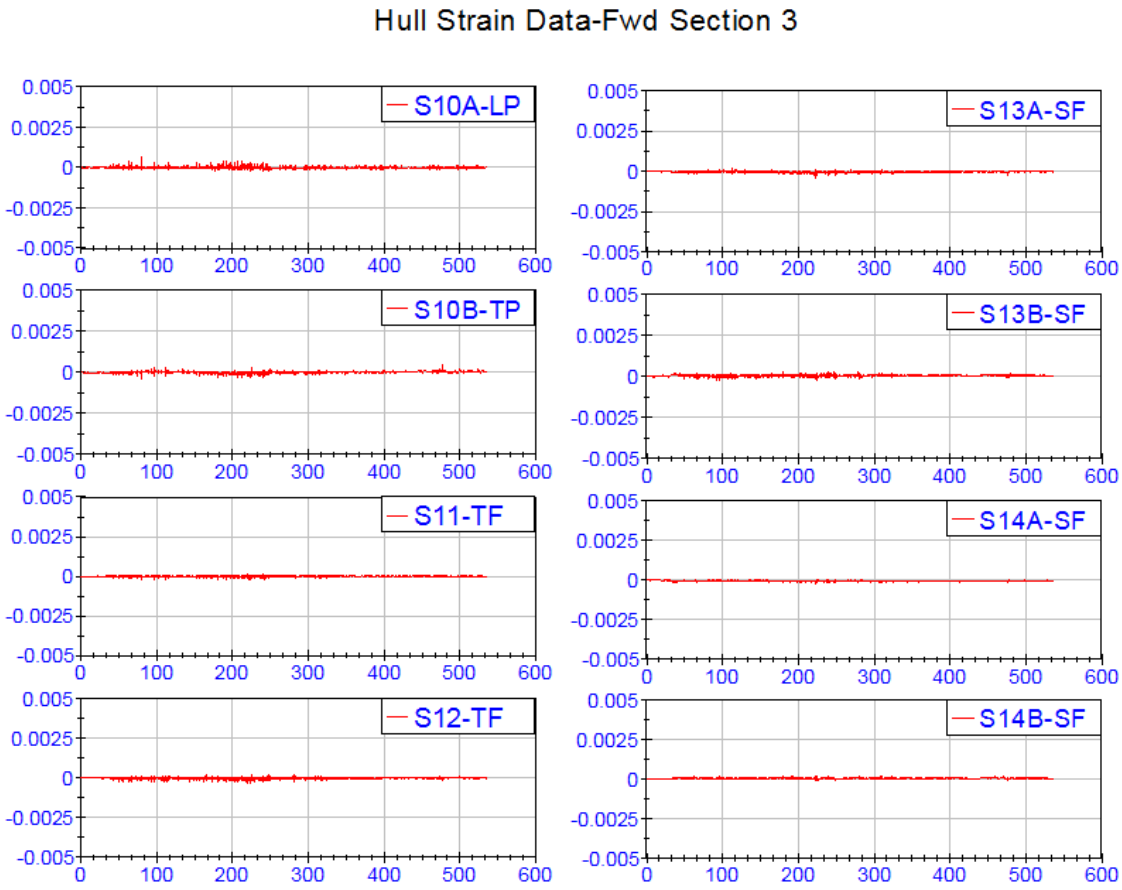


Figure 91 - Hull strain data - Inlet Run 7-14-12

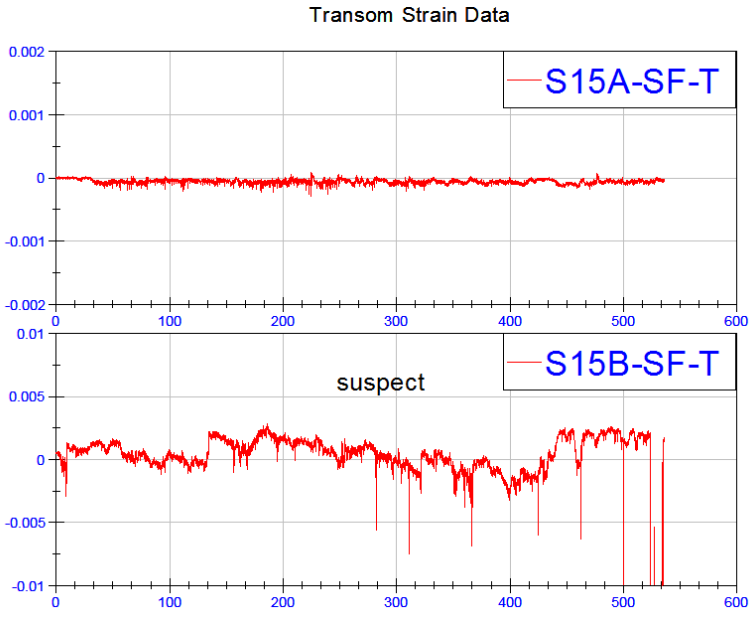


Figure 92 - Transom Strain Data - Inlet Run 7-14-12

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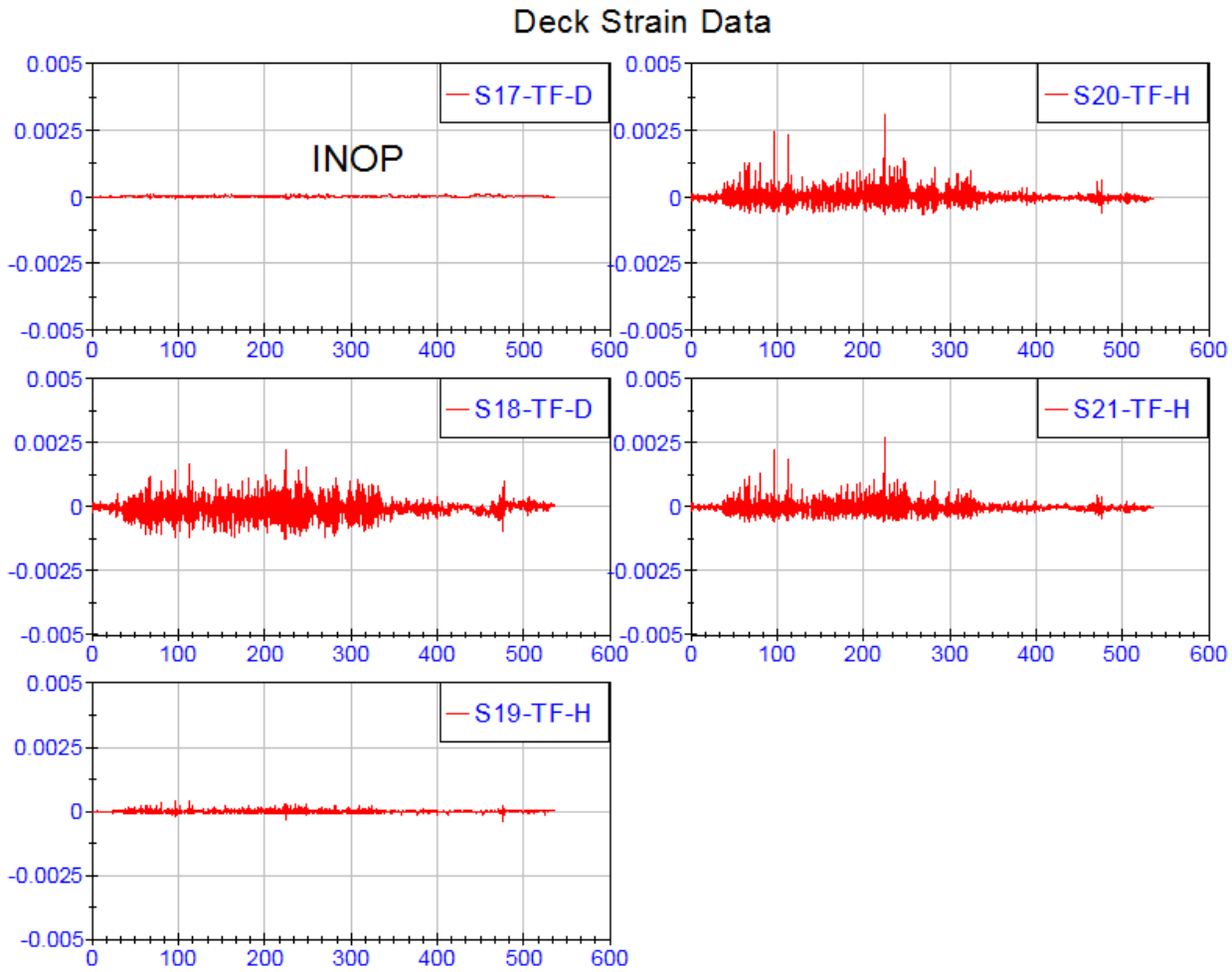


Figure 93 - Deck Strain Data - Inlet Run 7-14-12

Strain data in the hoist condition shows considerably lower strains than those observed in the full load condition. This is an expected result, as the craft payload is very large relative to the craft weight.

5.4.3.6 850B Structural Performance- Trailer Runs

The 850B was evaluated on the trailer in the lightly loaded condition. Trials were made on dirt roads in poor condition, paved roads in poor condition and over obstacles representing curbs and parking lot stops. Selected data from representative runs are shown below (figures 94-102). Processed runs for the trailer testing are provided in Appendix L.

The following trailer run was made over a dirt road in poor condition at 20 mph. The test was performed on November 17th and occurred in Palm Bay Florida. The 850B was lightly loaded.

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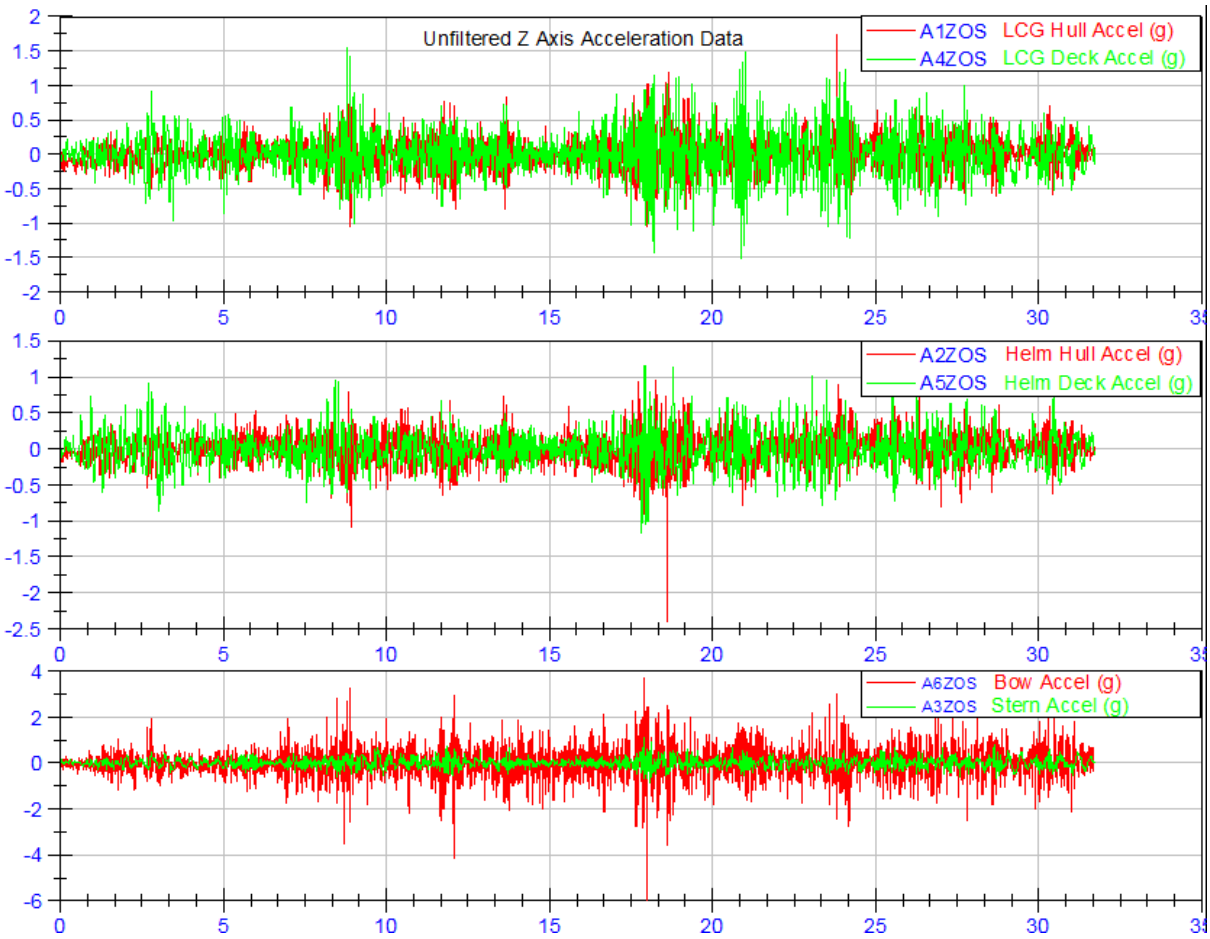


Figure 94 - Vertical Acceleration (g) Data for the 850B during trailer testing Nov 17 Dirt road in poor condition 20 mph

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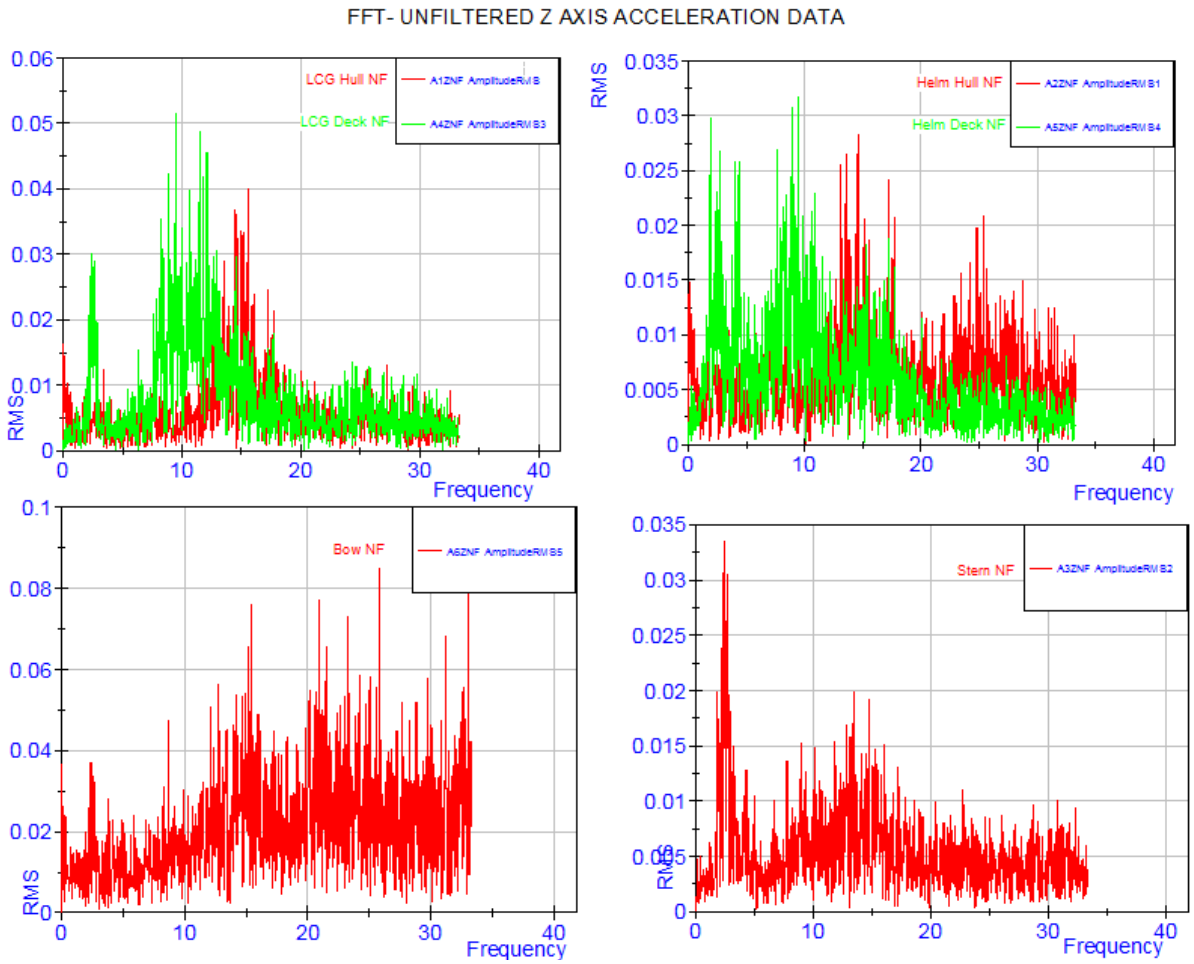


Figure 95 - FFT of the vertical acceleration data - RMS - Nov 11 trailer testing dirt road in poor condition at 20 mph

The accelerations during trailer testing were lower than those observed in ocean conditions. The above power spectrum supports the theory that the hull and deck have different natural frequencies. The following (figure 96) is a histogram plot of the vertical acceleration data.

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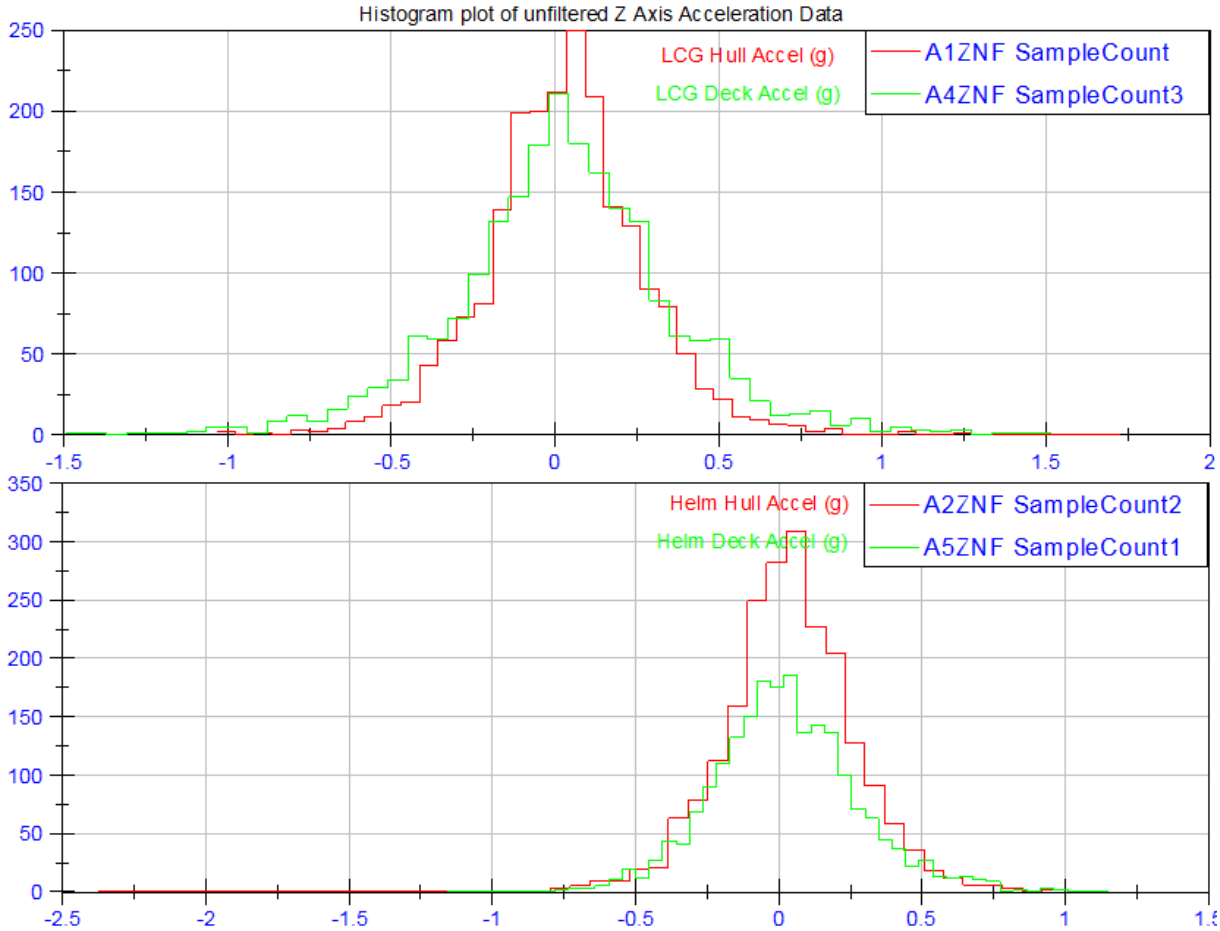


Figure 96 - Histogram plot of unfiltered vertical axis acceleration data. Nov 17 Dirt road in poor condition at 20 mph

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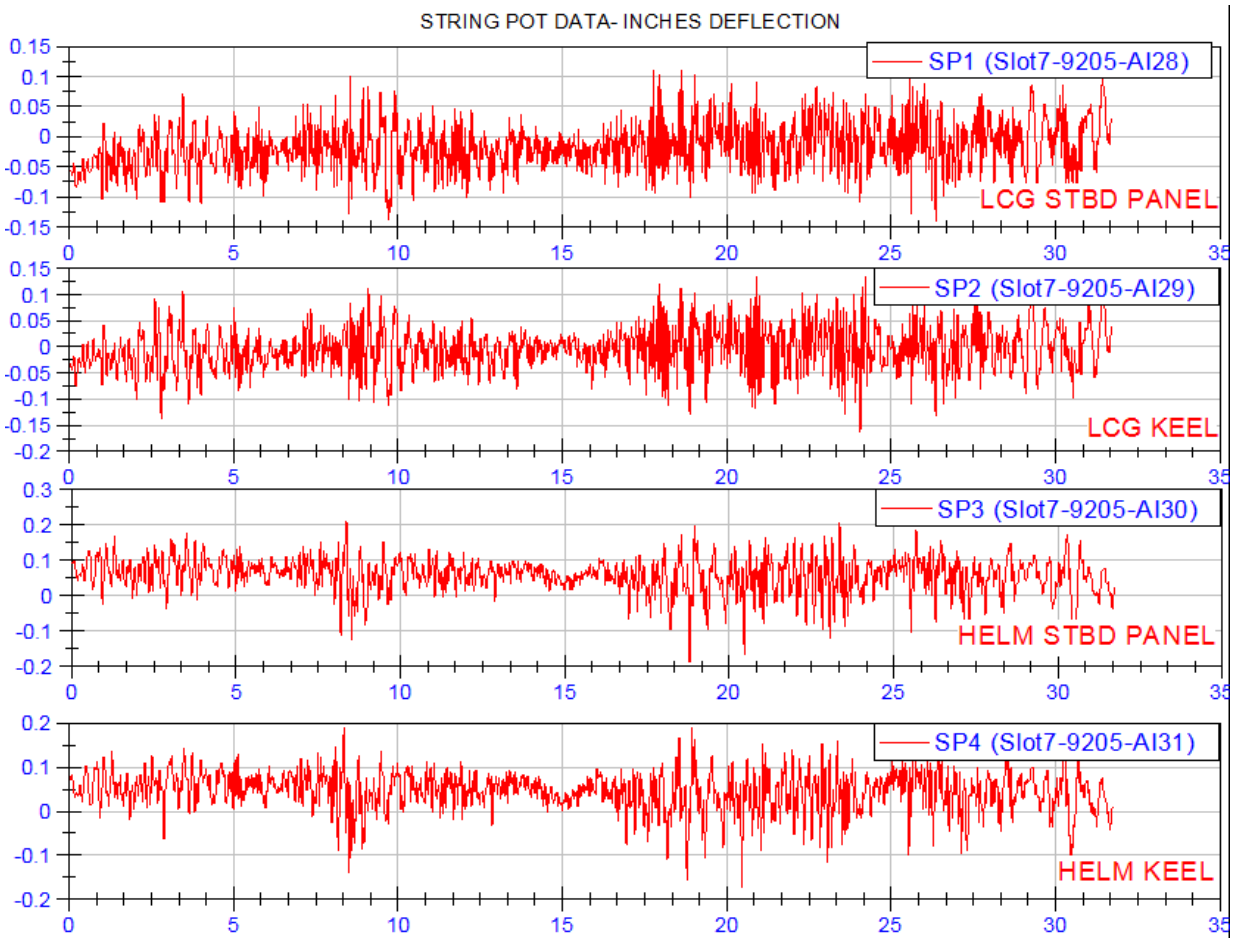


Figure 97 - String pot data showing combined hull and deck deflection (in.) - Trailer testing Nov 17 Dirt road in poor condition 20 mph

The string pot data for this trailer run (figure 97) shows that hull to deck deflections are lower when compared to runs made in the Indian River and/or ocean. The following are strain gauge data for this run (figures 98-102).

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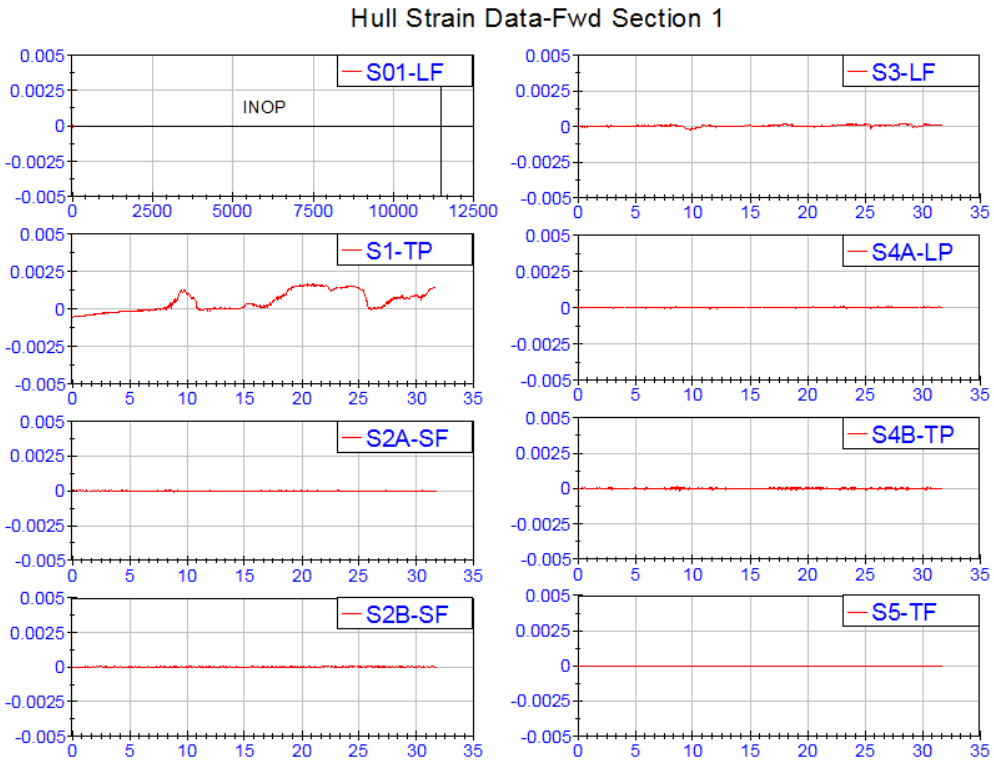


Figure 98 - Hull strain data Trailer Run Nov 17 Dirt road poor condition 20 mph

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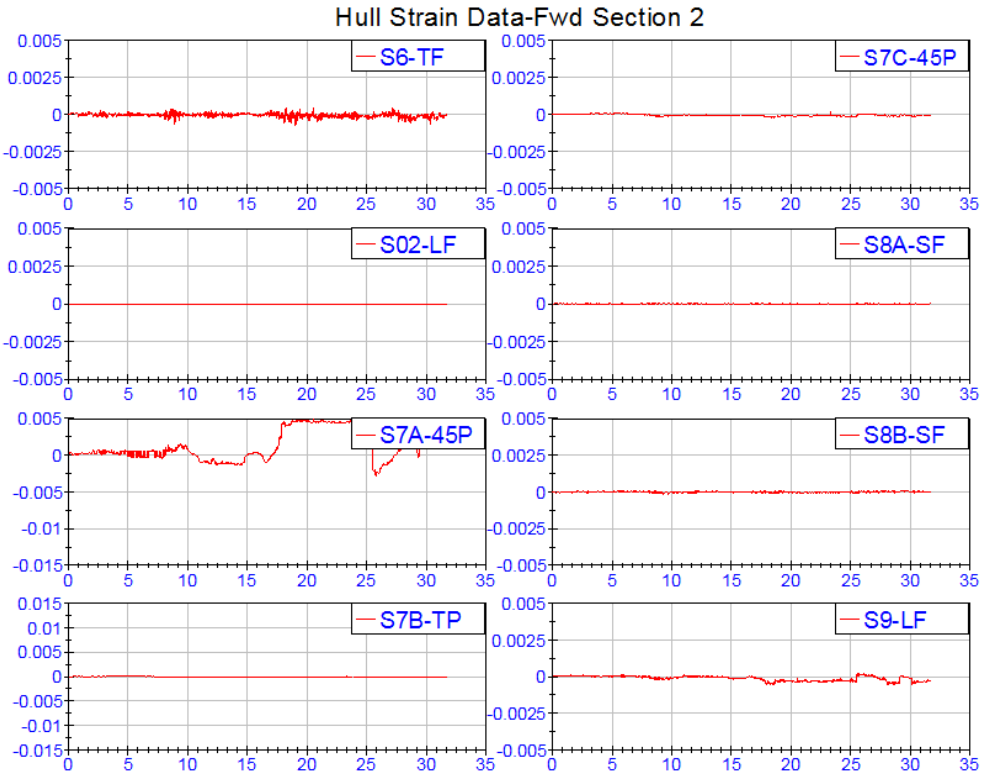


Figure 99 - Hull strain data - Trailer Testing Nov 17 Dirt road poor condition

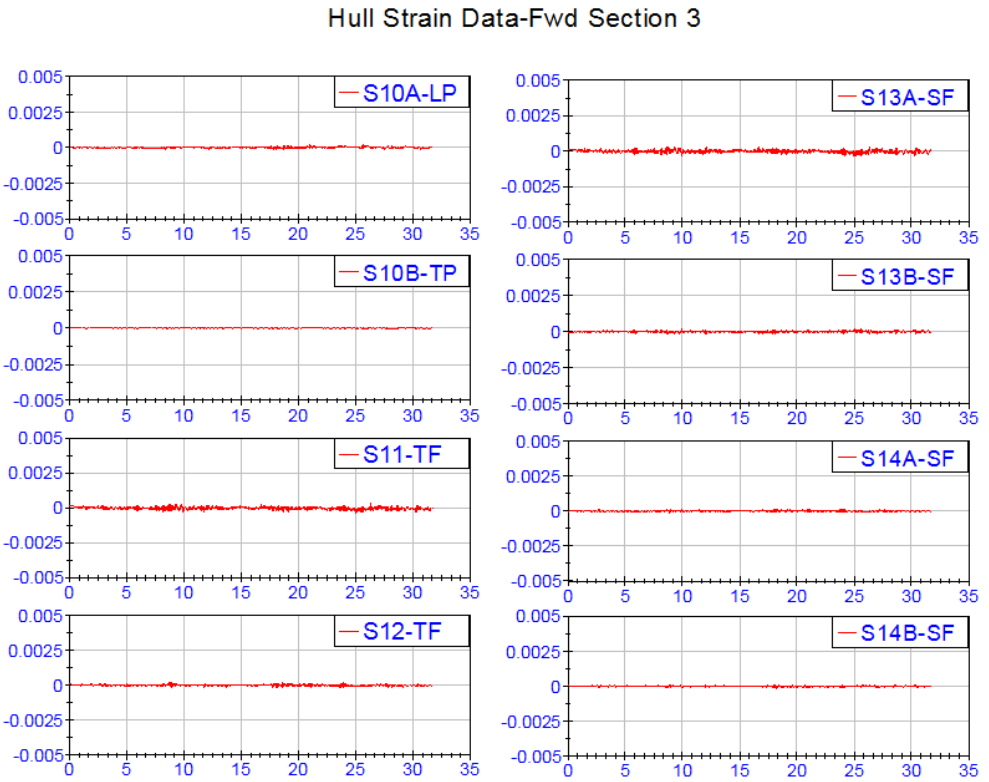


Figure 100 - Hull strain data - Trailer Testing Nov 17 Dirt road Poor Condition

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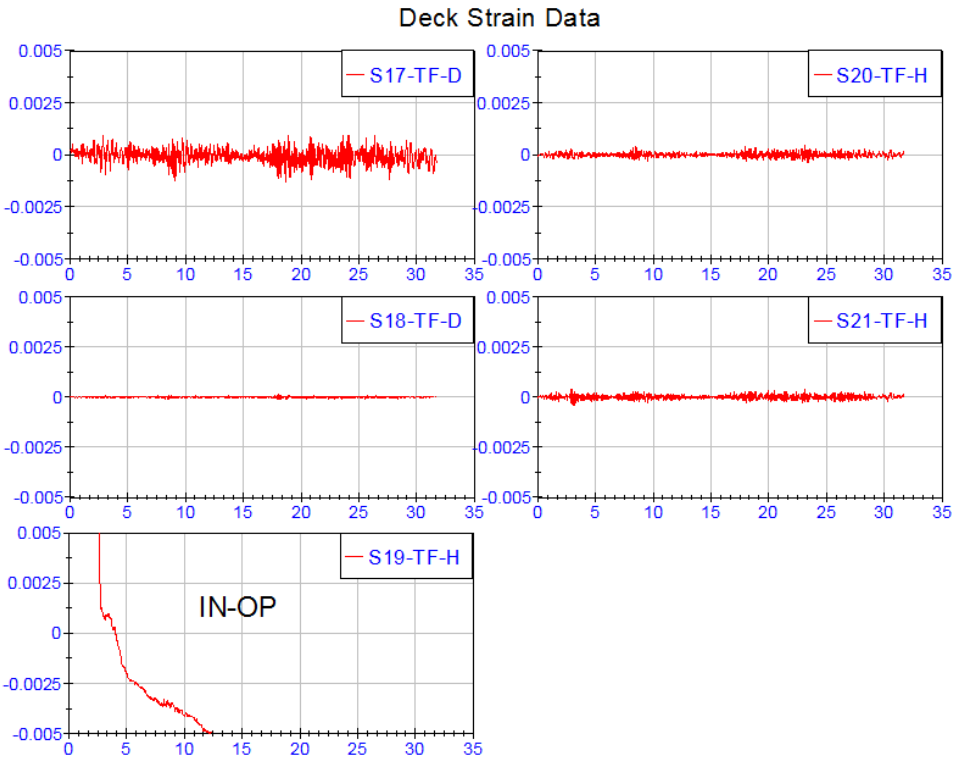


Figure 101 - Deck Strain Data

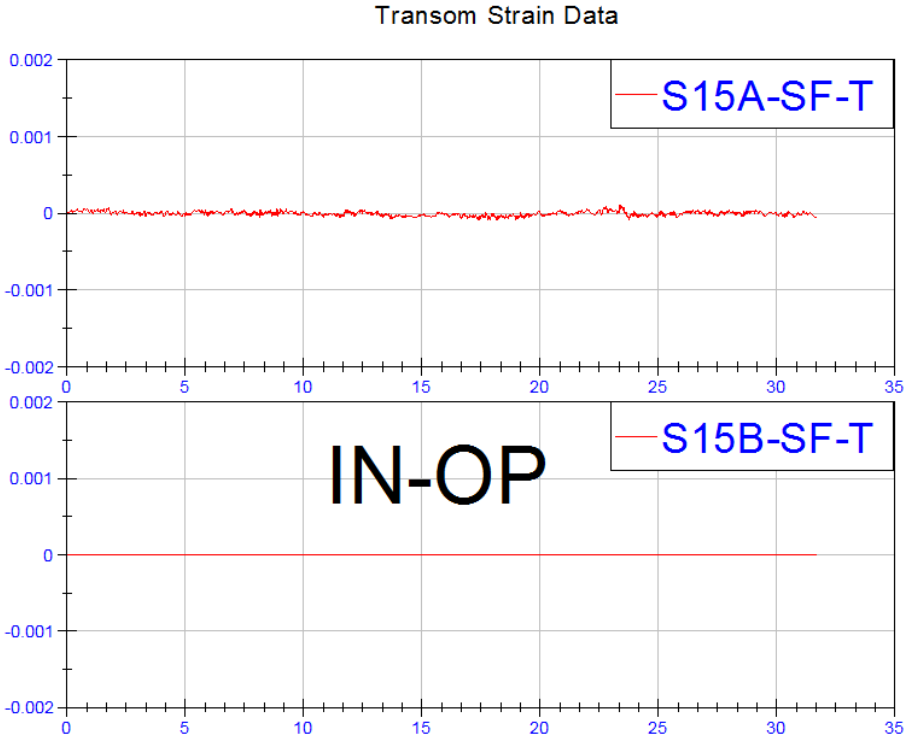


Figure 102 - Transom Strain Data

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Strain data during trailer testing indicates that the strain levels on the craft are low. Strain values measured were much less than those observed in the full load condition. Strain levels measured during testing indicate that the structure is adequate for trailering.

5.4.3.7 850B Air Support Trials

The 850B had limited trials with the hull to deck cavity pressurized. To pressurize the plenum between the hull and deck, we used a large 2 hp blower like the ones used for large inflatable structures such as children's recreational bounce houses. The blower was ducted to the forward stowage hatch of the 850B. Power was supplied to the blower during water trials with a deck mounted generator. The following figures show selected data for two trials. The first trial was performed with the boat on the trailer; the second trial was in the Indian River jumping a boat wake. Air support test data is presented in Appendix M.

The data presented below is from a trial on the trailer (figures 103-105). Five (5) people first bounced on the deck without the air support, followed by bouncing with the air support.

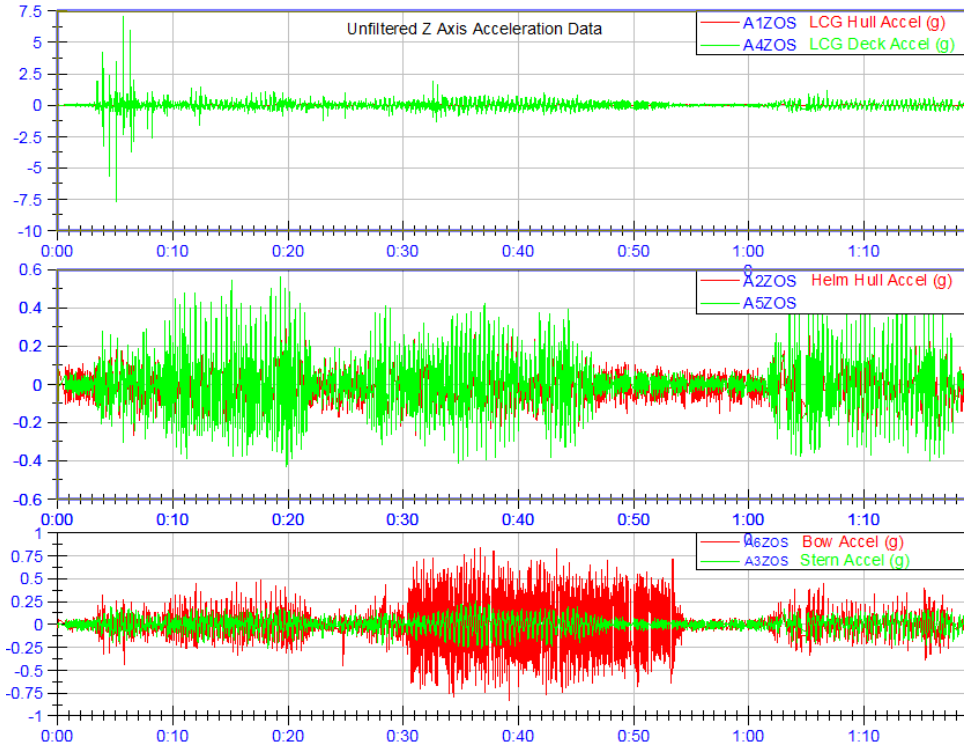


Figure 103 - Vertical Acceleration data (g) during hull pressurization test on trailer

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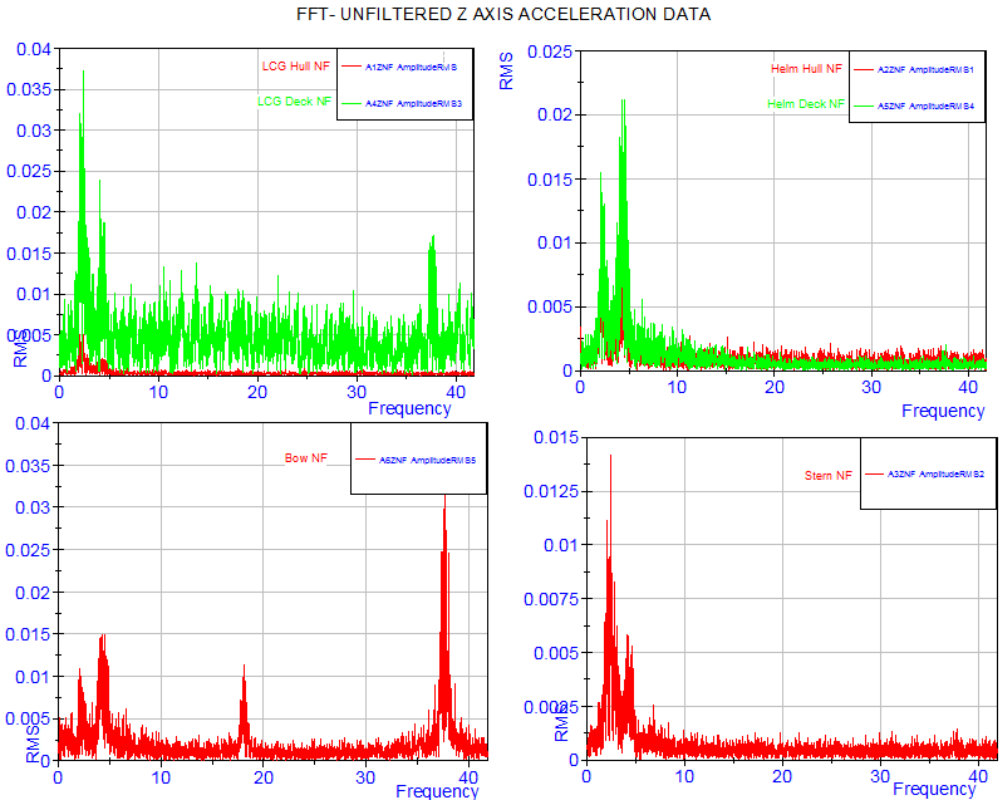


Figure 104 - FFT of the vertical acceleration data during hull pressure test on the trailer

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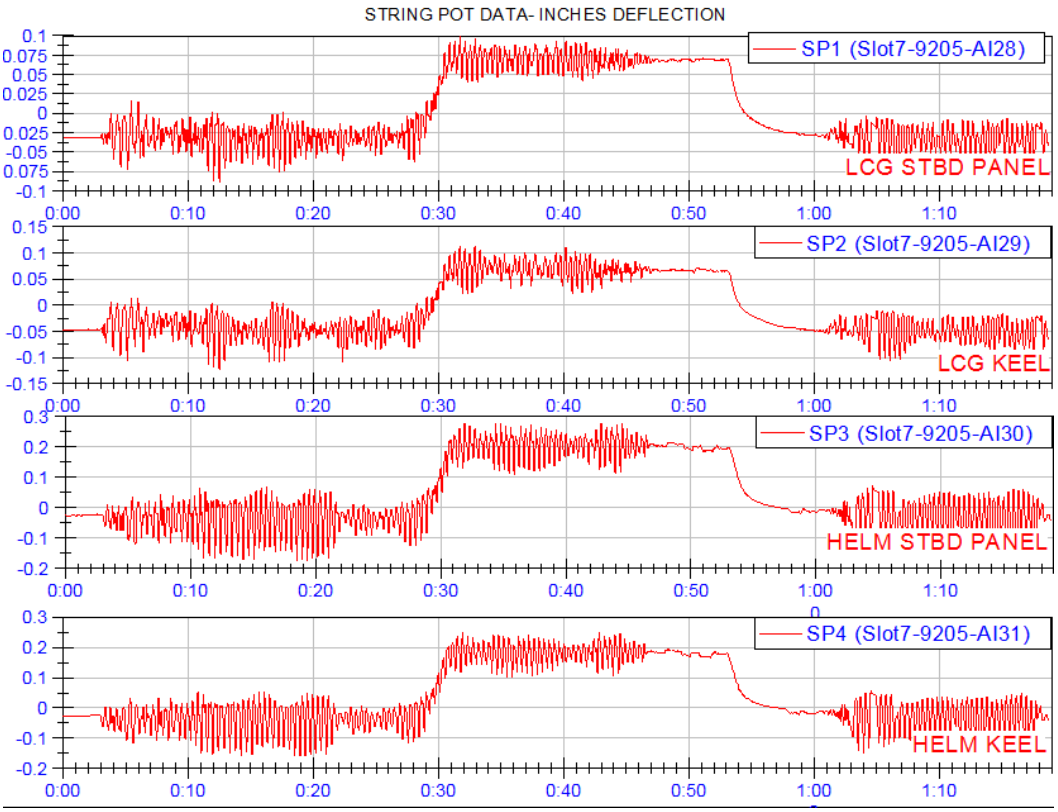


Figure 105 - String pot data showing hull to deck deflection during pressure testing while on the trailer

The string pot data (figure 105) clearly shows the pressurization event. The hull to deck cavity increased 0.2 inches at the helm string pots and just under 0.075 inches at LCG. The data seems to indicate a small reduction in the amplitude, in particular for the helm station. Below is the plot of the hull pressure during the test (figure 106). It is interesting to note that the amplitudes of the pressure during the people bouncing on deck event appear to be lower for the unpressurized condition. Strain data is shown in figure 107.

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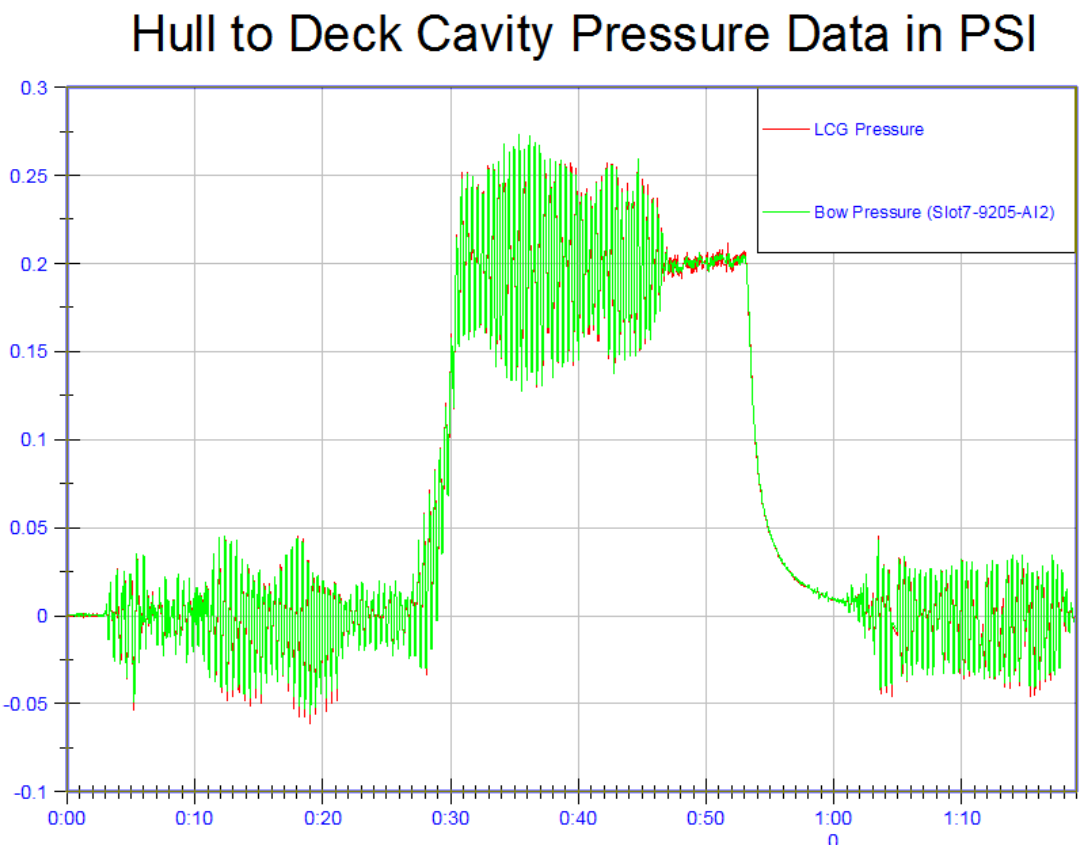


Figure 106 - Hull pressure (psi) during pressure testing while on the trailer

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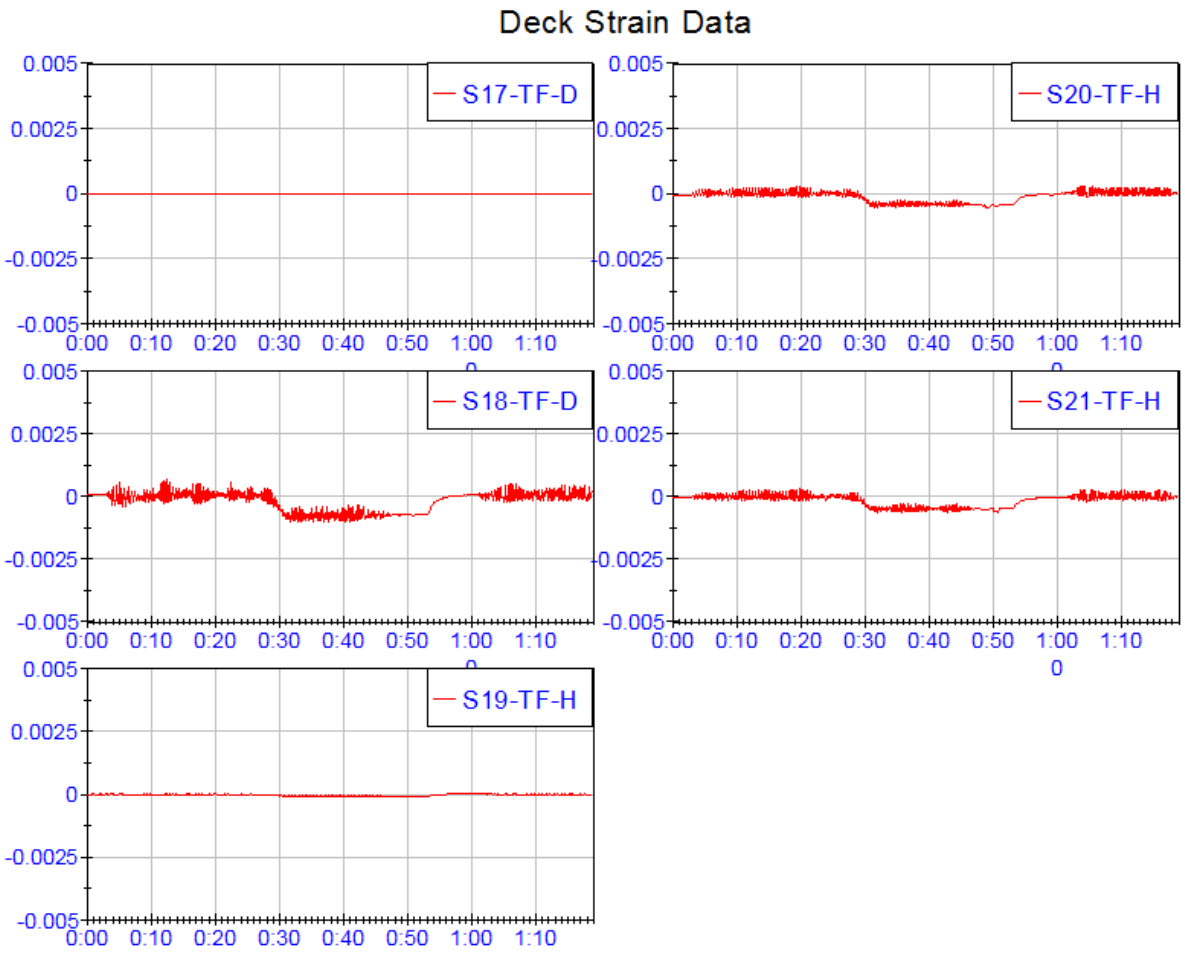


Figure 107 - Deck strain data during the pressure test while on the trailer

The strain data for several of the deck mounted strain gauges showed a noticeable change from the unpressurized to pressurized condition. The amplitude of the strains also appears to be slightly lower when the deck is pressurized during the bouncing condition.

The following (figures 108-110) are selected results of hull pressurization testing while operating in the Indian River at Melbourne, Florida on 19 August 2012.

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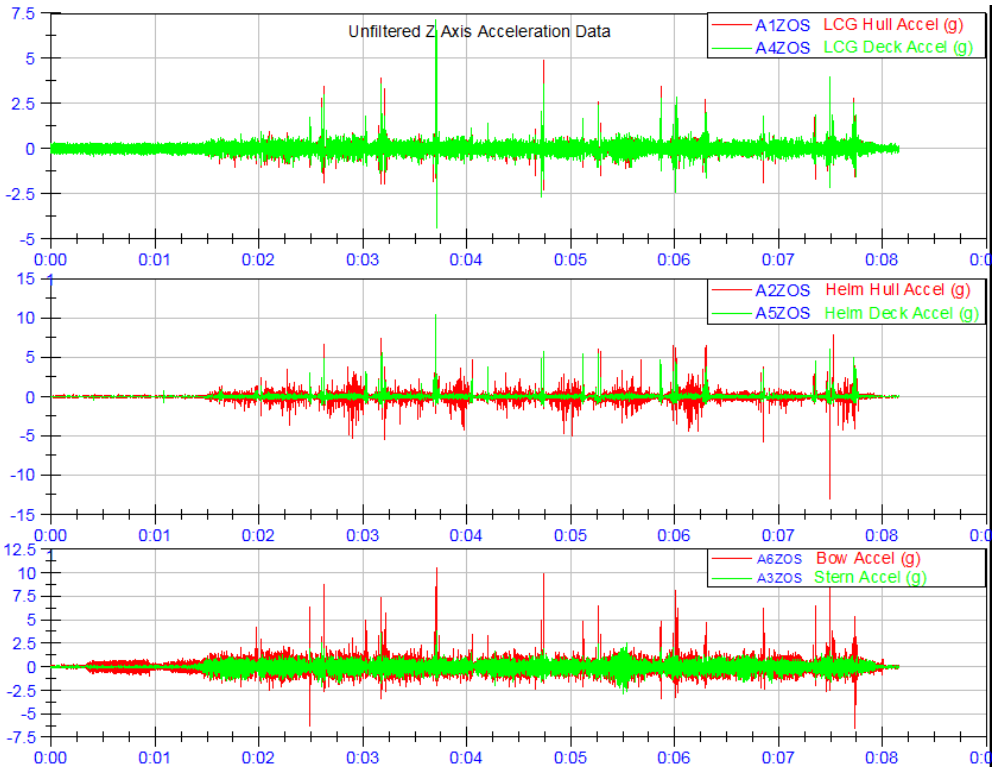


Figure 108 - Vertical Acceleration data (g) during hull pressurization wake jumping 19 Aug 12

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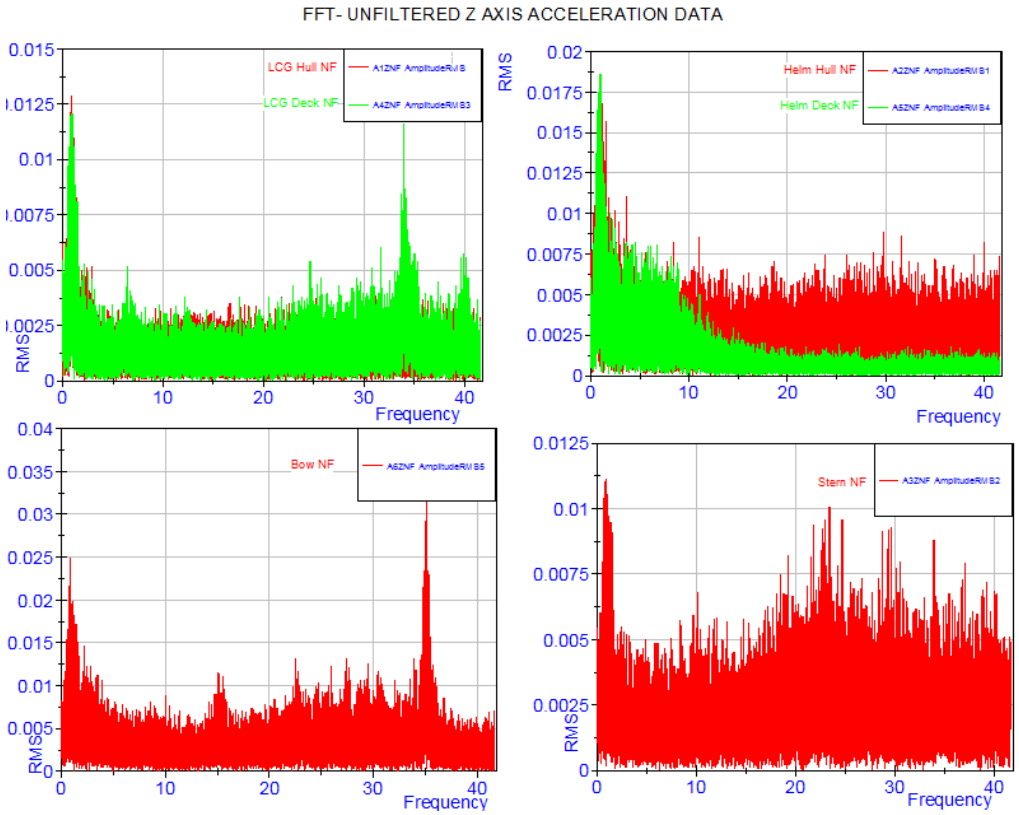


Figure 109 - FFT of vertical acceleration data for pressure test run wake jumping 19 Aug 12

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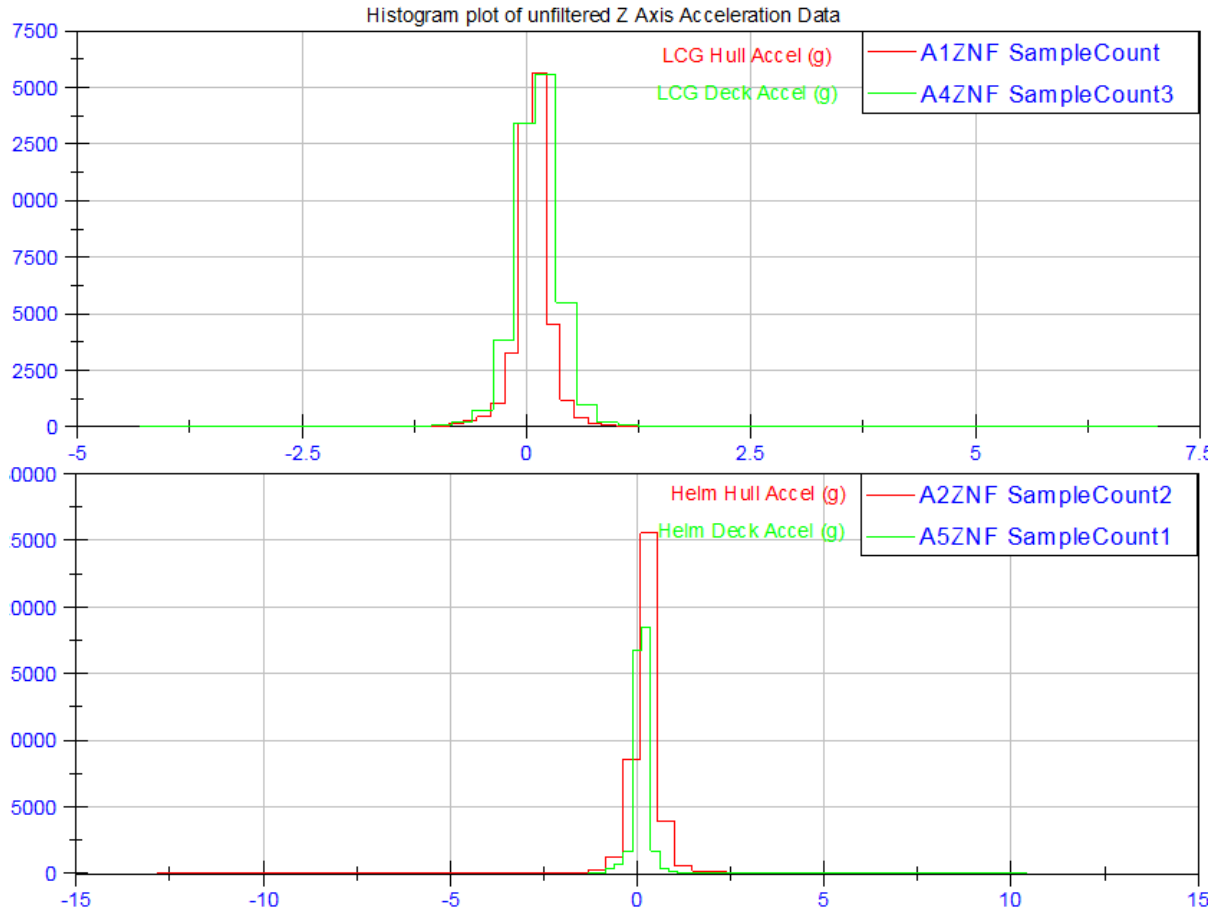


Figure 110 - Histogram plot of peak accelerations, hull pressure test, wake jumping 19 Aug 12

The acceleration data seems to indicate that the helm station and LCG station were affected differently by the pressurization. The FFT data indicates that more high frequency accelerations occur at LCG vs. the helm. Perhaps the added mass on the helm station versus the low mass at LCG could be the cause of this.

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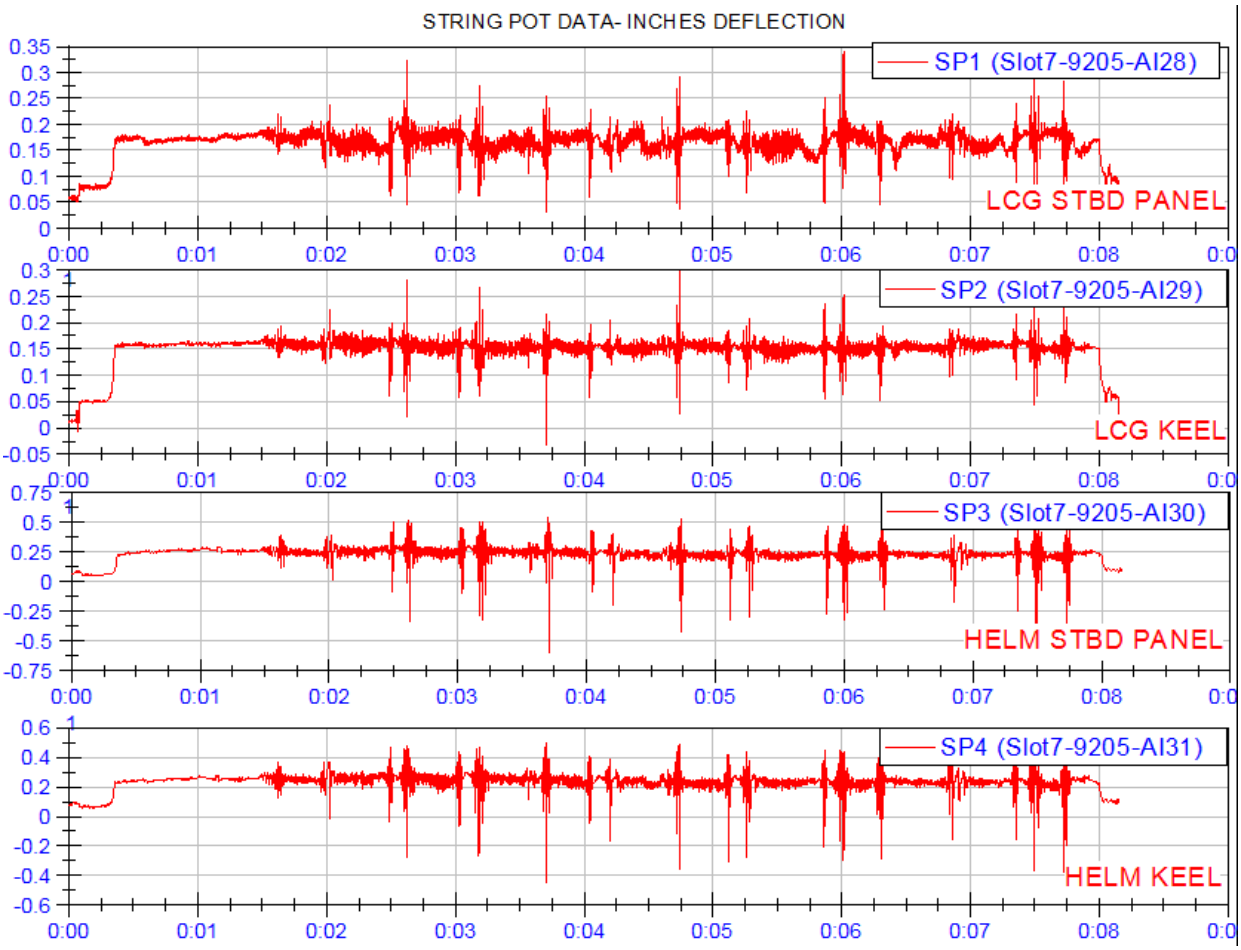


Figure 111 - String Pot data showing hull to deck deflection during pressure tests, wake jumping 19 Aug 12

Above is the string pot data during this run (figure 111). Hull deflection due to pressurization was somewhat greater on the water than that observed during pressure tests while the boat was on the trailer. Wave impacts are clearly seen. The plot below (figure 112) shows the pressure level in the hull to deck cavity during this test.

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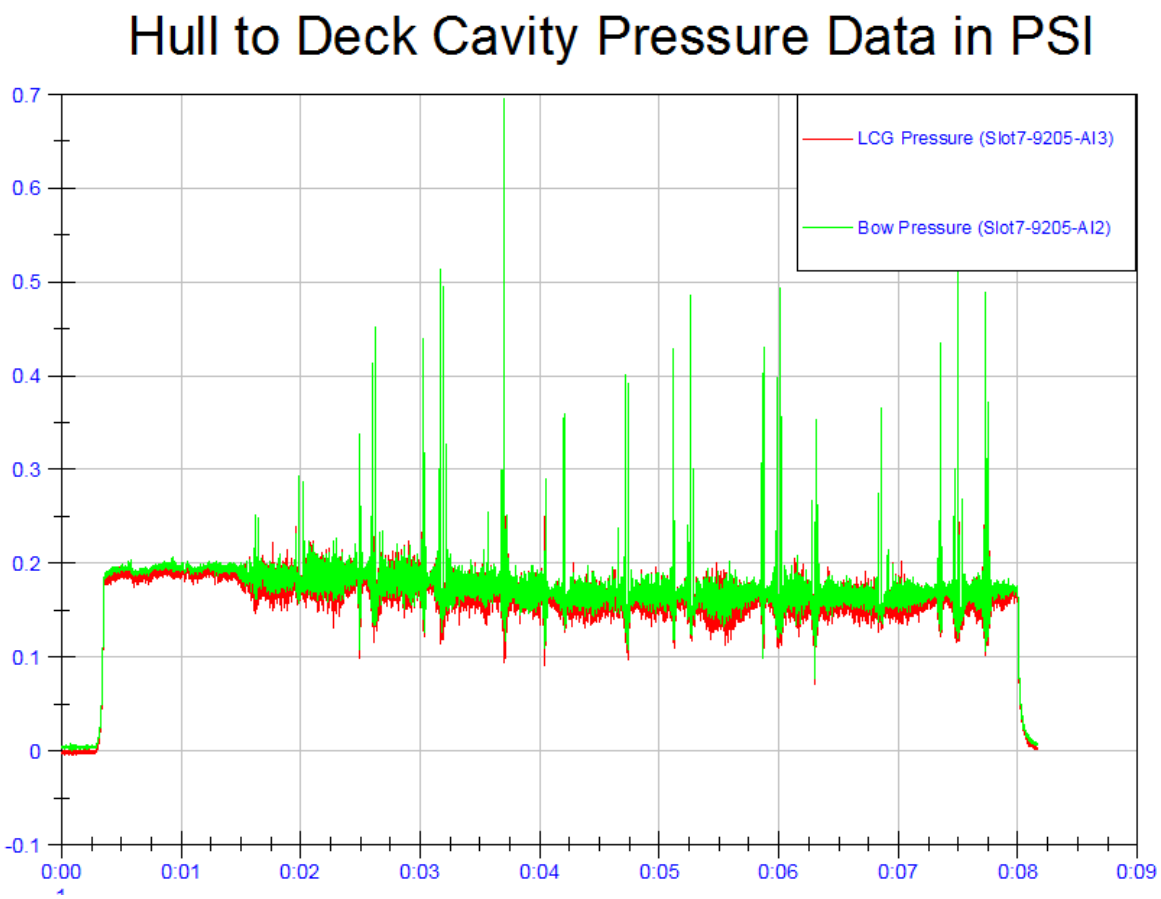


Figure 112 - Hull to deck pressure (psi) during pressure testing, wake jumping 19 Aug 12

The idea of hull pressurization is new. The data indicates that hull pressurization does have an effect on the hull to deck cavity height. Additional analysis on this data and additional evaluations with subsequent boats are needed to better understand and exploit the effect.

5.4.3.8 Summary of 850B Field Testing Results

A total of sixty nine (69) runs were evaluated with the 850B craft in a wide variety of operational conditions. The data indicates that the suspended deck concept does change the behavior from a rigid body to a more compliant structure. The data indicates that peak g loads are most reduced between the hull and deck when the craft is in the fully loaded condition. Strain data indicates that some hot spots on the structure should be monitored; however, for the most part the structure appears able to survive the operational environment. This will be verified by additional longer term evaluations by the Navy.

The concept of hull/deck cavity pressurization has merit. It has been shown that a noticeable increase in the hull to deck cavity dimension can be achieved. Additional work is needed to harness this pressurization to improve shock mitigation and to potentially further reduce stresses on the structure to allow for additional lightening. For the shock mitigation aspect it does appear

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that a dump valve or other method to allow depressurization during impact would allow for greater deflections and perhaps better shock mitigation. As to the structural aspect, it is anticipated that higher pressures may be needed to be able to reduce laminate and framing with the air providing support.

5.4.4 850B DDG Interface Trail

Our TPOC was able to arrange for the 850B to undergo a ship interface trial with USS Roosevelt (DDG-80). We supported the effort bringing the craft to Mayport, Florida and assisting with the trial. Detailed measurements were taken by CCD staff.

The craft was hoisted onto the Roosevelt's aft boat position from the trailer using a large crane.



Figure 113 - 850B hoisting onto USS Roosevelt (DDG-80)

It was noted that the shipboard ladder/bumper pole was keeping the craft from landing center on the supports (figures 114-115).

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Figure 114 - 850B Lowering on ship's cradle



Figure 115 - Ladder interferes with fit. Deflating the collar allows craft to fit

The collar was deflated and the craft did fit into position. With the props in the down position it appeared to have similar clearance to the hoist as the 7M craft fwd. CCD personnel recorded

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dimensions. Indications are that the ladder/bumper pole needs to be offset inboard, the collar modified or the craft beam reduced.



Figure 116 - 850B on Cradle with Collar Deflated

After this initial trial the craft was loaded to the hoist load (verified weight with scale) and lifted using the ship's hoist. The 850B was then swung outboard and rotated so clearance could be checked. No issues were noted.

5.4.4.1 850B Trial Run with Navy Crew

Navy personnel assisting with the effort were very excited to see the boat. They were very impressed with the space the craft offered and were very positive on the outboards. A test run was conducted, as there were several experienced boat operators who were very interested to see how the boat performed.

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Figure 117 - 850B in Dock Area, Mayport Trial Run

The 850B was loaded with 14 persons for runs in the inlet and in the intercoastal. Nearest wave buoy data was 2.3 ft and agreed with observed conditions. Data was collected during the entire run, which is included in Appendix N Mayport Trial Run. The 14 people easily fit on the boat. It was noted that aft seating would be beneficial. At speed offshore (40MPH) passengers in front of the console moved aft due to craft pitch motion. At this point Mr. Davis (boat operator) pointed out the advantage of the forward cockpit, which is that the boat operator being forward feels the motion and can slow down, better protecting passengers. A run in the intercoastal was made at high speed. At this load a speed of 53-55mph was achieved.

5.4.4.2 850B DDG Interface Trials Summary

The interface trials indicate that the craft can fit on the DDG ship with minor modification to account for the increased beam of the craft. From a technical standpoint offsetting the boarding ladder and forward vertical support would be the simplest resolution. Both the ladder and the support are bolted on, and it appears that a simple offset bracket could be used to increase the beam. If this solution is undesirable, decreasing the collar width in the interference locations would be the next best choice. Wing Inflatables (Arcata, Ca), which produced the collar for this craft, feels this can be done. The other potential solution is reducing the beam of the craft; this is the least desirable option, as it removes very valuable deck space and requires retooling the hull and deck.

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5.5 850B Performance Summary

The 850B has demonstrated weight savings and shown its ability to meet and exceed the load and performance objectives of the project. Field testing did reveal some durability issues at the hull to deck interface, and these have been addressed and modified. Additional durability testing by the Navy will help validate the long term durability of the craft and may identify other design aspects that need modification. It is anticipated that modifications would be minor and localized and would not have a major effect on overall weight. Evaluations under heavy sea conditions showed that the hull structure appears to be adequate. In particular the single skin transom, which is a radical departure from conventional construction, is performing very well and measured strains are low.

In effecting the modifications, it was demonstrated that single skin structures are easy to identify damaged areas and easy to make repairs when compared to sandwich structures. Framed single skin structures tend to show damage on the framing system, while sandwich structures typically experience damage to the core material. Core damage may be hidden and progress until a large section is damaged. With the framed single skin structure, damage tends to localize at the frame damage point and does not have the tendency to propagate. Repairing a sandwich structure can be very complex and expensive; repairing the single skin structure typically involves placing additional reinforcement over the damaged area.

Experience with the 850B deck and hatch rework on this project demonstrated that modifications to single skin structures are easy to execute. The application of bonded-on elements to make repairs and modifications is another interesting aspect. This method worked very well for making repairs and modifications that would be difficult to execute as it would require lamination to the bottom of the hatches. This points to some very interesting opportunities to execute field repairs in the event of damage. Laminate stock material could be supplied and repairs executed by bonding laminate to the damaged areas with structural adhesive.

Related to maintainability is access to be able to make repairs. During testing of the 850B portable deck mounted fuel tanks were used. This was done to allow instrumentation of the hull and to allow monitoring of the structure. Deck mounted fuel tanks as part of the design would keep the hull to deck cavity accessible, and the deck mounted tanks could provide needed seating for passengers.

5.6 11M Prototype Design, Manufacturing, Testing and Results

5.6.1 11M Prototype Design and FEA

Two design variants were evaluated for the 11M prototype. These were called the Advanced 11M design and the Fiberglass 11M design. The Advanced design features a hull laminate that uses lightweight fibers from Innegra and carbon. Innegra is a low density polypropylene fiber.

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These hull laminates use a carbon fiber center with Innegra fiber skins. The Fiberglass design is a lower risk design similar to that used in the 850B. The 11M prototype design requirements are provided in Appendix O.

After evaluations the weights for the two designs were projected and compared. These results were conveyed to the Navy TPOC. The advanced laminate did result in weight savings over the fiberglass design; however the weight savings were small relative to the risk of using new materials that do not have significant history of use in marine or combatant craft structures. In concurrence with the TPOC it was decided that significant weight savings was obtainable with the lower risk fiberglass design and this design was selected for subsequent fabrication and evaluations.

Appendices P and Q contain the Advanced and Fiberglass design presentations. Excerpts from the fiberglass design are presented below. Selected drawings follow (figures 118-120).

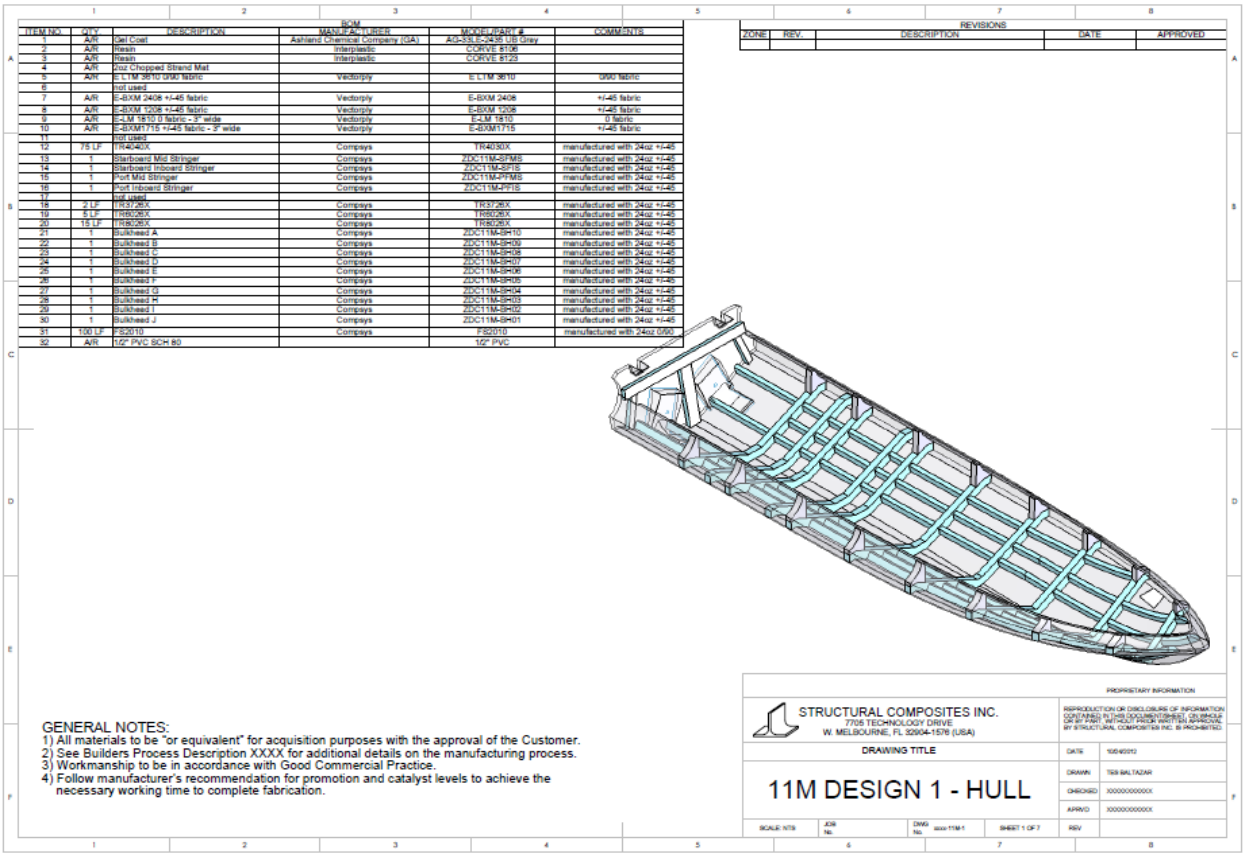
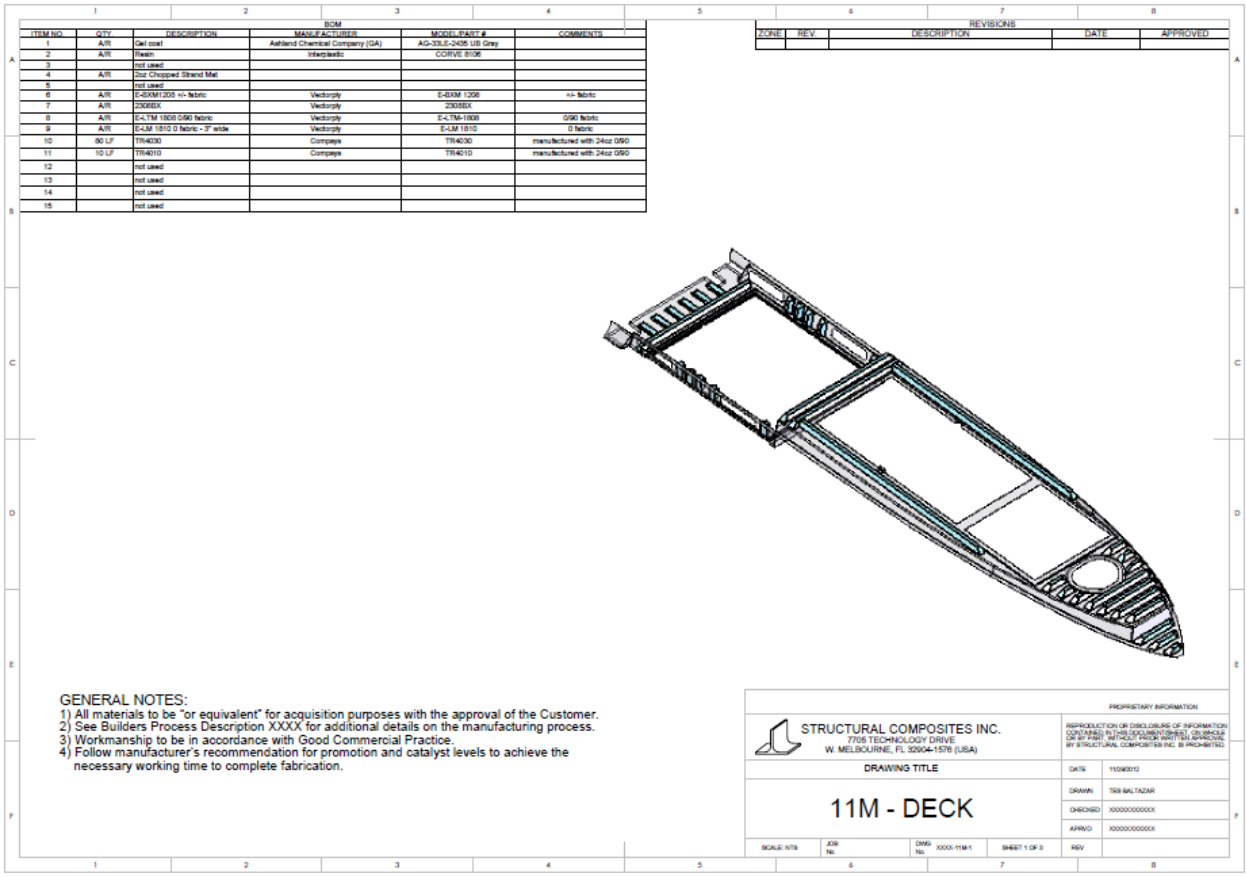


Figure 118 - Hull Drawing for the 11 M Fiber glass Design

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BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-30LE-2406 UB Grey	
2	A/R	Resin	Interplastic	CORVE 8106	
3		not used			
4	A/R	2oz Chopped Strand Mat			
5		not used			
6	A/R	E-BXM1208 +/- fabric	Vectorply	E-BXM 1208	+/- fabric
7	A/R	2308BX	Vectorply	2308BX	
8	A/R	E-LTM 1808 0/90 fabric	Vectorply	E-LTM-1808	0/90 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	80 LF	TR4030	Compsys	TR4030	manufactured with 24oz 0/90
11	10 LF	TR4010	Compsys	TR4010	manufactured with 24oz 0/90
12		not used			
13		not used			
14		not used			
15		not used			

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED

GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

STRUCTURAL COMPOSITES INC.
7705 TECHNOLOGY DRIVE
W. MELBOURNE, FL 32904-1578 (USA)

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DRAWING TITLE

11M - DECK

DATE	11/29/2012
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APPVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 1 OF 3

Figure 119 - Deck Drawing for the 11M Fiber Glass Design

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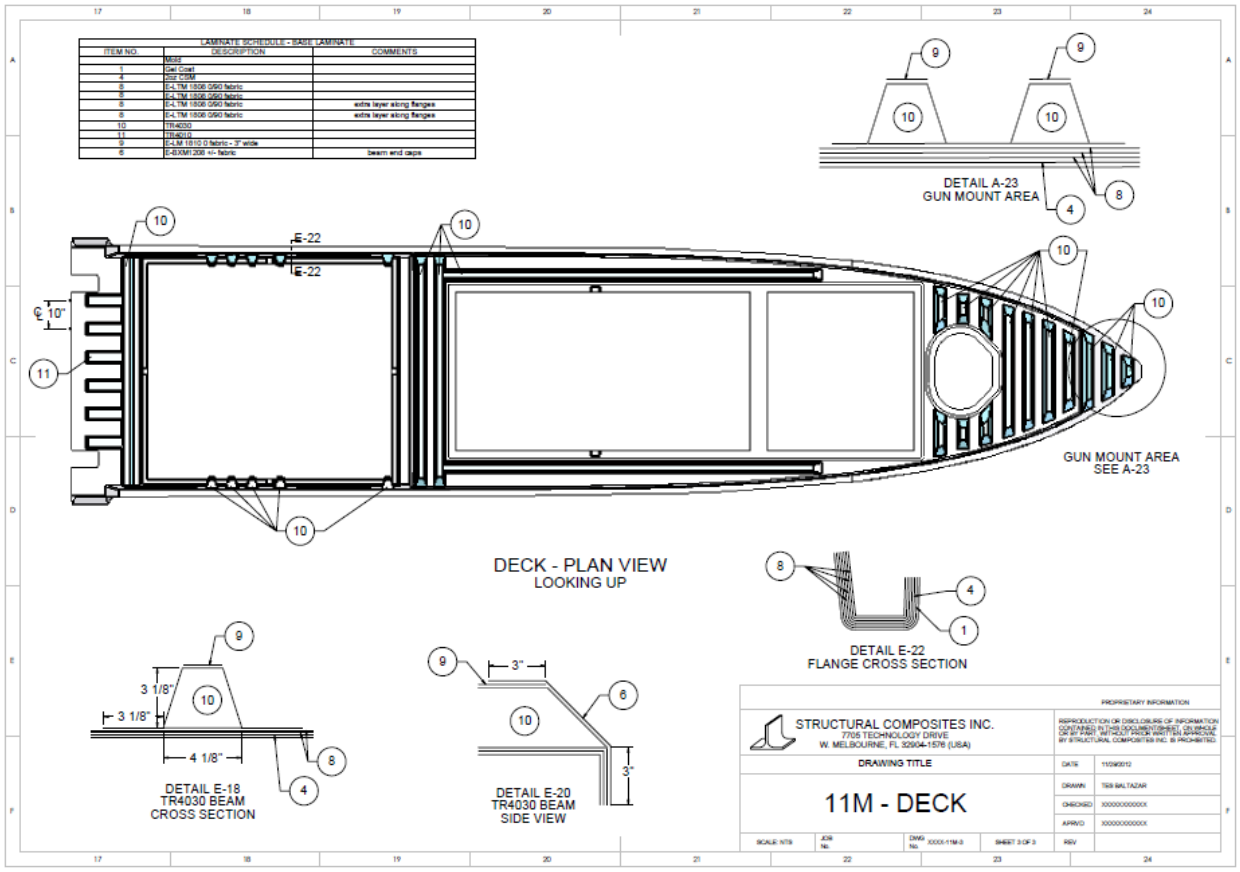


Figure 120 - Deck Detail Drawing for the 11M Fiber Glass Design

Below is the matrix for the FEA analysis for the 11M fiberglass design (figure 121). The 11M advanced design has a similar matrix. Eleven (11) load cases were evaluated, including small area slam analysis, lift point analysis, gun mount analysis and trailer loading analysis. As with the 850A and 850B design, 10 psi was selected as the pressure for the small area slam.

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Load Case	Load ID	Description	Pressure	Load lb
1	AI	Aft Inboard, SAS	10psi	--
2	AO	Aft Outboard, SAS	10psi	--
3	AMI	Aft Mid Inboard, SAS	10psi	--
4	AMO	Aft Mid Outboard, SAS	10psi	--
5	FMI	Fwd Mid Inboard, SAS	10psi	--
6	FMO	Fwd Mid Outboard, SAS	10psi	
7	FI	Fwd, Inboard	10psi	
8	BLP	Boat Lift Points	--	105,600
9 10	GML GMT	Gun Mount-Longitudinal Transverse	--	
11	TLR	Trailer Analysis	--	51000

Figure 121 - Load cases evaluated for the 11M Fiber Glass Design

Below is the FEA grid and loaded area for load case 3 which is a small area slam with the 10 psi load applied to the shaded area (figure 122). Following the FEA grid is the results of that particular FEA (figure 123). Figure 124 provides weight projections for both the Advanced and Fiberglass designs. Results from this and other FEA analyses indicate that the design would be adequate.

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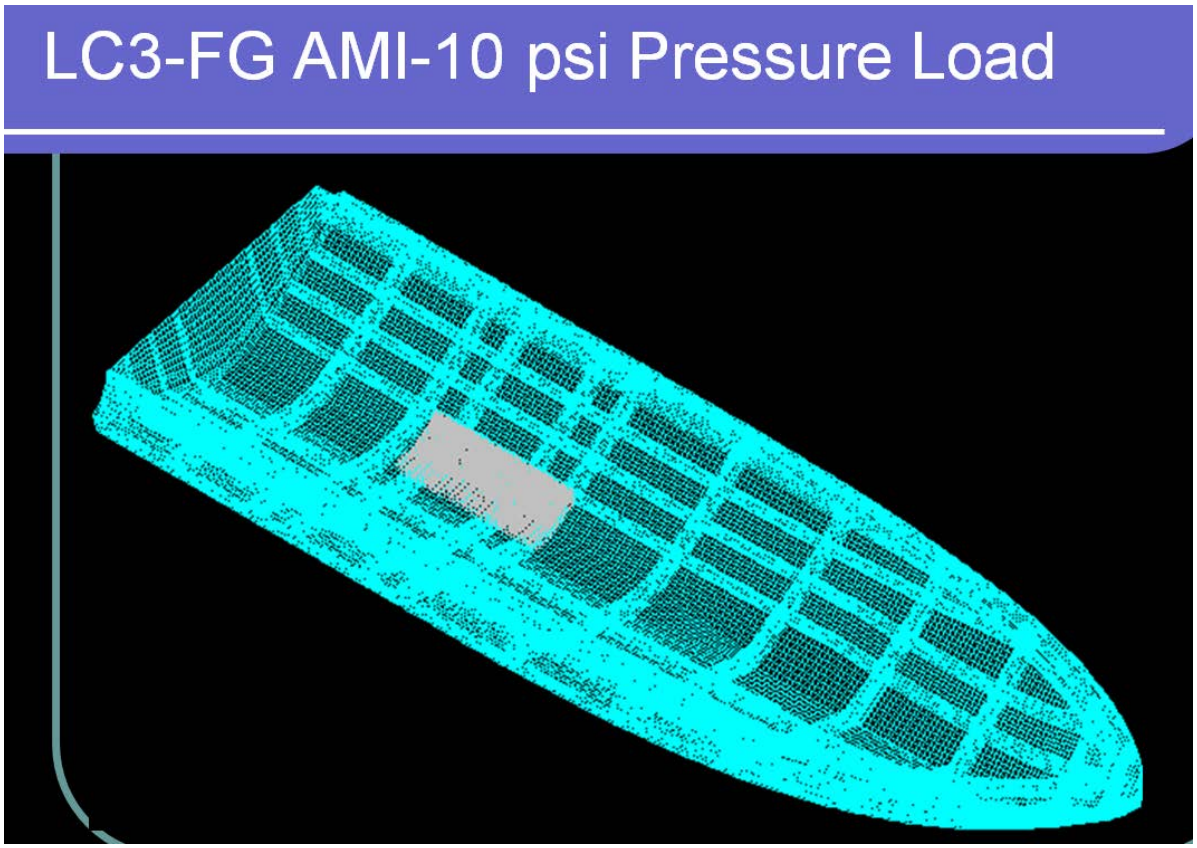


Figure 122 - Small Area Slam FEA GRid for the 11M Fiber Glass Design

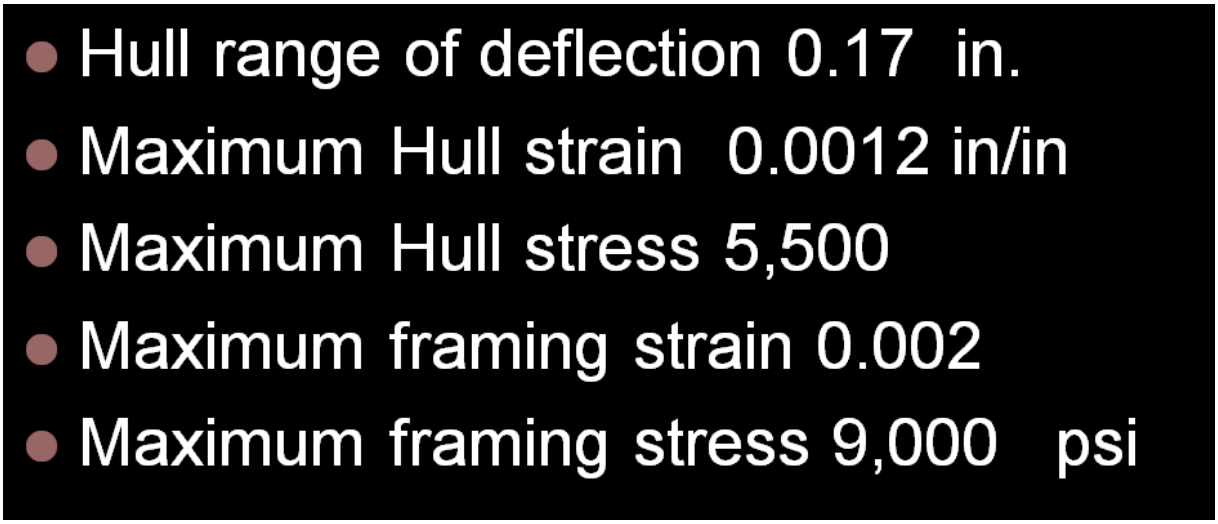


Figure 123 - Results from the above FEA for the 11M Fiber Glass Design

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Component	AL – Weight (lb)	FG – Weight (lb)
Hull	930-960	1070-1100
Deck	470-490	470-490
Total Weight Hull and Deck	1400-1450 55% to 57% Savings from Baseline	1540 - 1590 50 to 53% Savings from Baseline

Figure 124 - Weight Projections for both the Advanced and Fiber Glass designs

5.6.2 11M Prototype Manufacturing

The 11M prototype was fabricated using the 11M Fiberglass design methodology. The part was fabricated at Oceanus Inc, located in Washington state, in November 2012. Oceanus is the supplier of molded parts to Zodiac Boats. The 11M hull was infused in a single infusion which included the longitudinal and transverse framing. This differed from the process used on the 850B, where the hull was infused with the longitudinals and the transverse frames later hand laminated. This process was used on the 850B to minimize risk. With Oceanus having more infusion experience, and with them witnessing the infusion of a 7M SBIR craft along with SC experience building the prior craft, it was decided to proceed with the single infusion. Photos of the manufacturing are presented below (figures 125-127).



Figure 125 - 11M prototype with preforms installed

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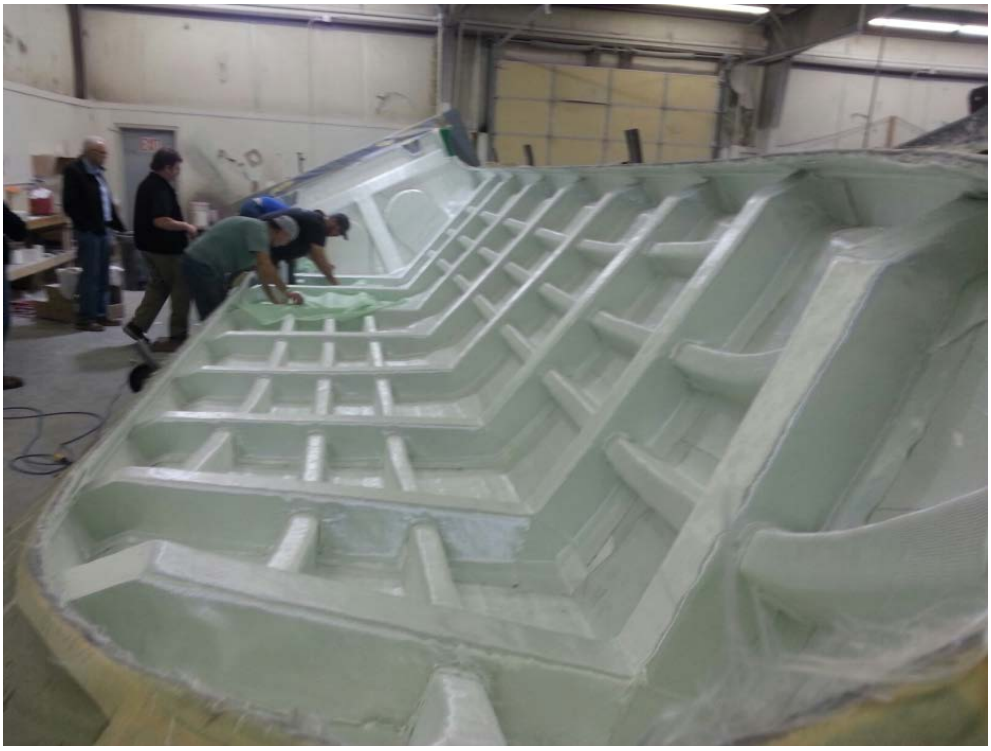


Figure 126 - 11M prototype infusion preparation

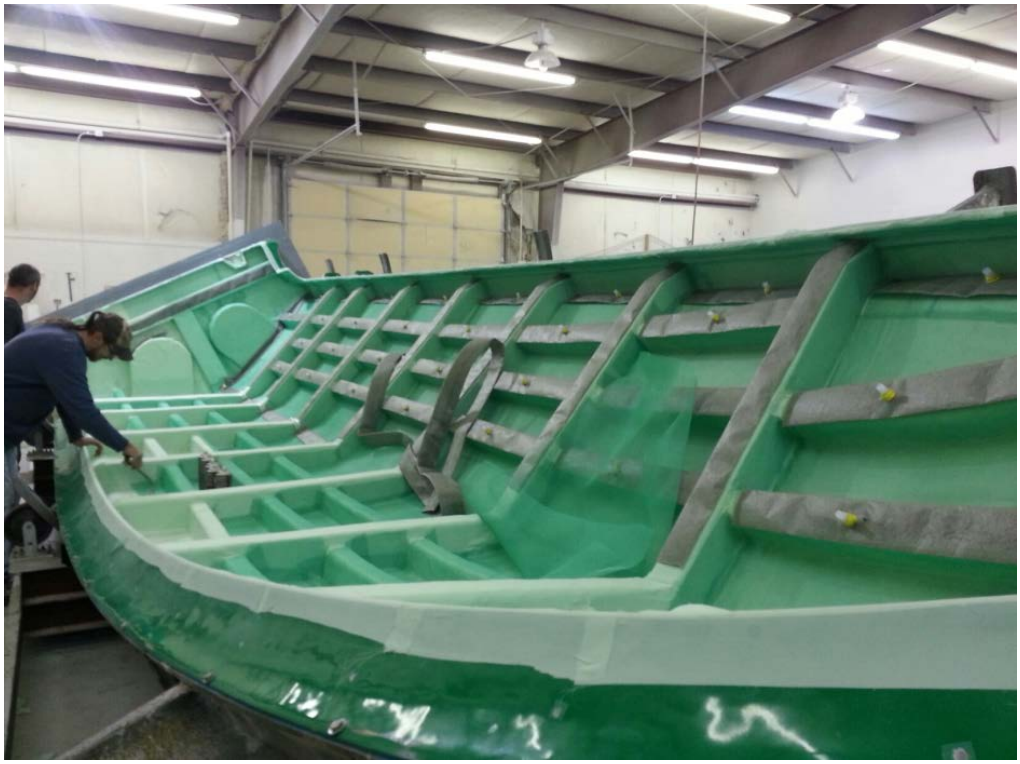


Figure 127 - 11M prototype infusion preparation

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5.6.3 11M Prototype Testing – Weight Evaluation Results

Parts were fabricated and weights were provided by Oceanus. Baseline data for hulls and bonded hull and decks were available. Baseline weights for hatches were not available.

Table 23. 11M Prototype and Baseline Weight Data.

Part	Weight	Baseline	Savings
Hull	1295	2275	43%
Bonded Hull and Deck	1950	3100	37%
Engine Hatches	184	ND	
Aft Deck Hatch	74	ND	
Mid Deck Hatch	84	ND	
Fwd Console Hatch	100	ND	
Total	2392		

5.6.4 11M Prototype Testing – Drop Tests

The 11M prototype underwent a series of drop tests to evaluate the structure. The drop tests occurred in Vancouver Canada near the location of Zodiac Boats. The test article consisted of the bonded hull and deck of the 11M prototype with the forward hatches temporally secured. Lift hardware was installed. The craft was loaded per the figure below (figure 128) to bring the craft to a total weight of just under 16,000 lbs, which was the limit for the release mechanism.

The figure (128) below shows the standard configuration of the Zodiac 11M. Following this is the ballast plan for the drop test (figure 129). Ballast consisted of lead weights, sandbags and water bags placed in the hull cavity on top of plywood sheets. Water bags were used on the deck (figure 130).

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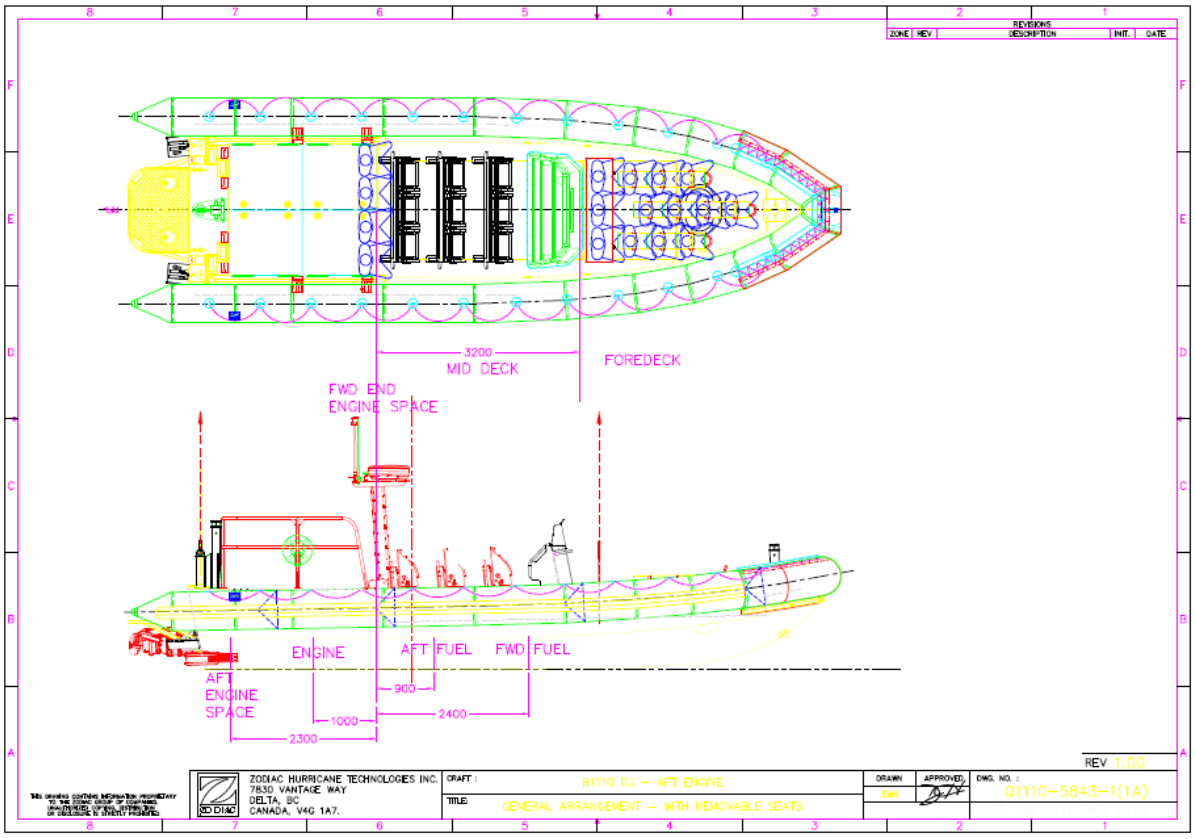


Figure 128 - Zodiac drawing showing standard configuration

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SCH 1110 - Drop Test Ballast									
ISSUE - Nov 26/2012									
ITEM	QUANTITY	WEIGHT EACH (KG)	TOTAL WEIGHT (KG)	TOTAL WEIGHT (LBS)	LOCATION	LCG - from front of eng space (mm)			
Hull/deck	1	884.7	884.7	1950	N/A	N/A			
Aft Deck plate	1	33.6	33.6	74	N/A	N/A			
Mid Deck plate	1	38.1	38.1	84	N/A	N/A			
Fwd/console Deck plate	1	45.4	45.4	100	N/A	N/A			
Engine box lid	4	21	84	185	N/A	N/A			
Collar from HP79	1	125	125	276	N/A	N/A			
TOTAL HULL/DECK/COLLAR				2669					
HULL BALLAST									
Jet guard	1	40	40	88	Aft Engine Space	-2900	88		
Trim tabs	1	15	15	33	Aft Engine Space	-2720	33		
Tow post/weapon foundation/aft lift point	1	70	70	154	Aft Engine Space	-2720	154		
Waterjets	2	215	430	948	Aft Engine Space	-2720	948		
Driveline	2	30	60	132	Aft Engine Space	-2150	132		
Raw water, exhaust	2	70	140	308	Aft Engine Space	-2150	308		
						Aft Engine Space	1664	lbs.	2300 mm aft
Engine/gear	2	720	1440	3174	Engine	-1000	3174		
Engine foundations	2	30	60	132	Engine	-1000	132		
Fuel system	2	20	40	88	Engine	-1000	88		
						Engine	3394	lbs.	1000 mm aft
Ventilation	2	10	20	44	Fwd Engine Space	0	44		
Batteries	4	22	88	194	Fwd Engine Space	0	194		
						Fwd Engine Space	238	lbs.	at fwd end of engine space
Aft Fuel tank W/ FUEL	1	495	495	1091	Aft Fuel Cavity	900	1091		
						Aft Fuel Cavity	1091	lbs.	900 mm fwd.
Fwd Fuel tank W/ FUEL	1	495	495	1091	Fwd Fuel Cavity	2400	1091		
						Fwd Fuel Cavity	1091	lbs.	2400 mm fwd.
TOTAL HULL BALLAST			3393	7478					
ITEM	QUANTITY	WEIGHT EACH (KG)	TOTAL WEIGHT (KG)	TOTAL WEIGHT (LBS)	LOCATION	LCG - from front of eng space (mm)			
DECK BALLAST									
Aft railing	1	20	20	44	Mid Deck	-1230	44		
Bolsters	3	70	210	463	Mid Deck	1360	463		
Pax @ bolsters	9	75	675	1488	Mid Deck	1360	1488		
Pax behind bolsters	4	75	300	661	Mid Deck	0	661		
Mast w/ antennae/lights	1	60	60	132	Mid Deck	150	132		
Deck hardware	1	20	20	44	Mid Deck	1300	44		
Console	1	200	200	441	Mid Deck	2700	441		
						MID DECK	3273	lbs.	
Forward locker	1	30	30	66	Foredeck	3480	66		
Pax @ fwd locker	3	75	225	496	Foredeck	3480	496		
Adjust for 11 meter collar	1	60	60	132	Foredeck	4600	132		
Forward seats	10	15	150	331	Foredeck	4680	331		
Pax @ forward seats	8	75	600	1322	Foredeck	4680	1322		
Bow post	1	40	40	88	Foredeck	3960	88		
						FOREDECK	2435	lbs.	
TOTAL DECK BALLAST			2570	5708					
TOTAL TEST WEIGHT				15855					

Figure 129 - Weight plan for the 11M drop testing

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Figure 130 - Hull cavity ballast for 11M prototype drop test

5.6.5 11M Prototype Drop Testing – Instrumentation and Sensor Locations

The 11M prototype was outfitted with accelerometers, strain gauges and, string pots (to measure hull to deck deflections). The following figures (131-135) show the locations and identification codes for each of the sensors.

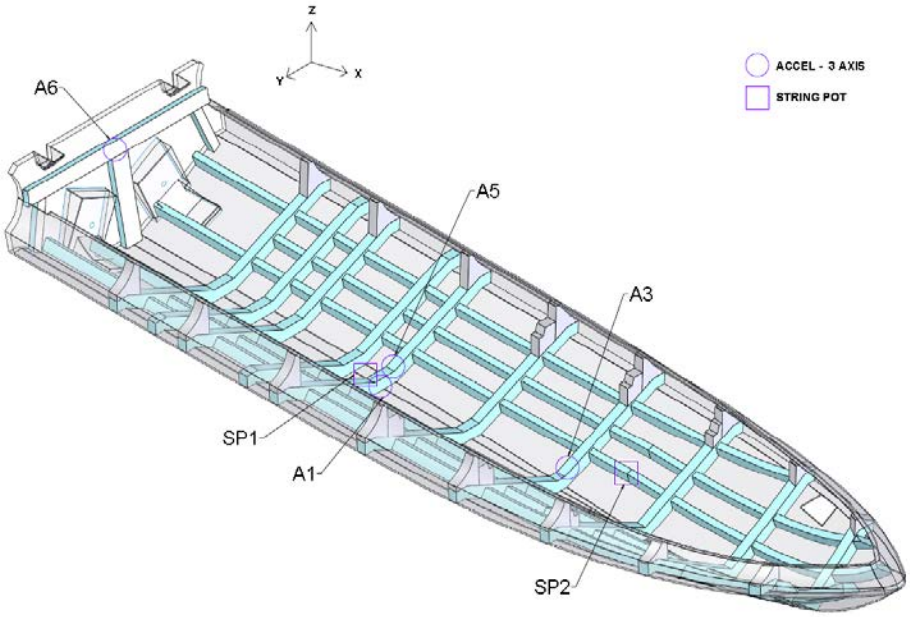


Figure 131 - Accelerometer and string pot locations on the 11M prototype hull

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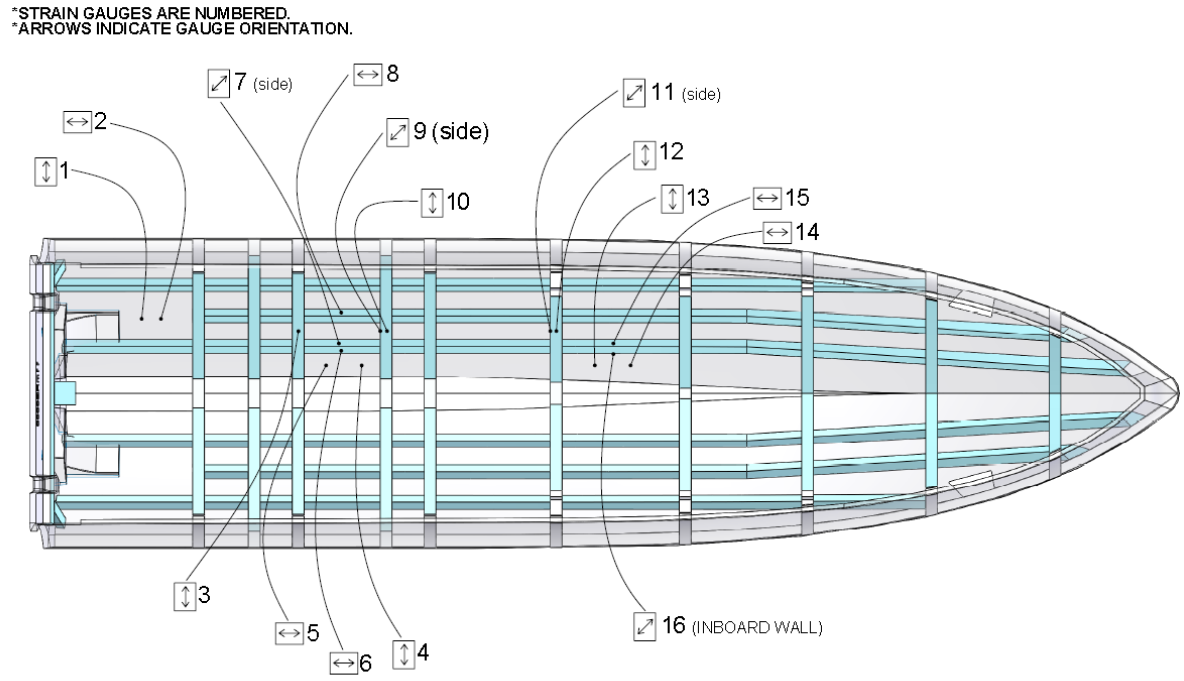


Figure 132 - Hull Strain Gauge locations for the 11M prototype

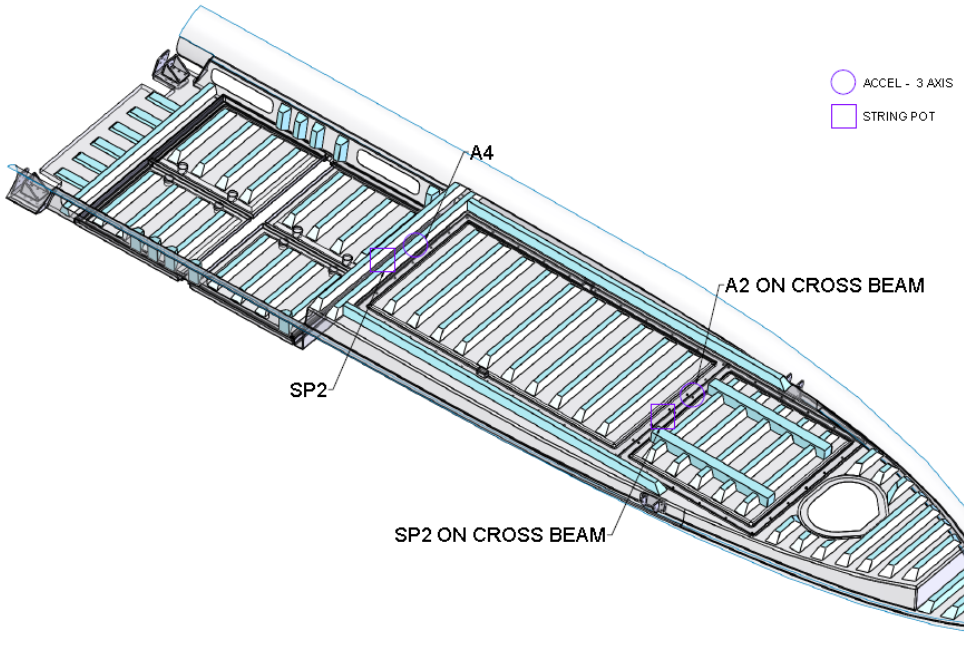


Figure 133 - Location of deck accelerometers and string pots for the 11M prototype

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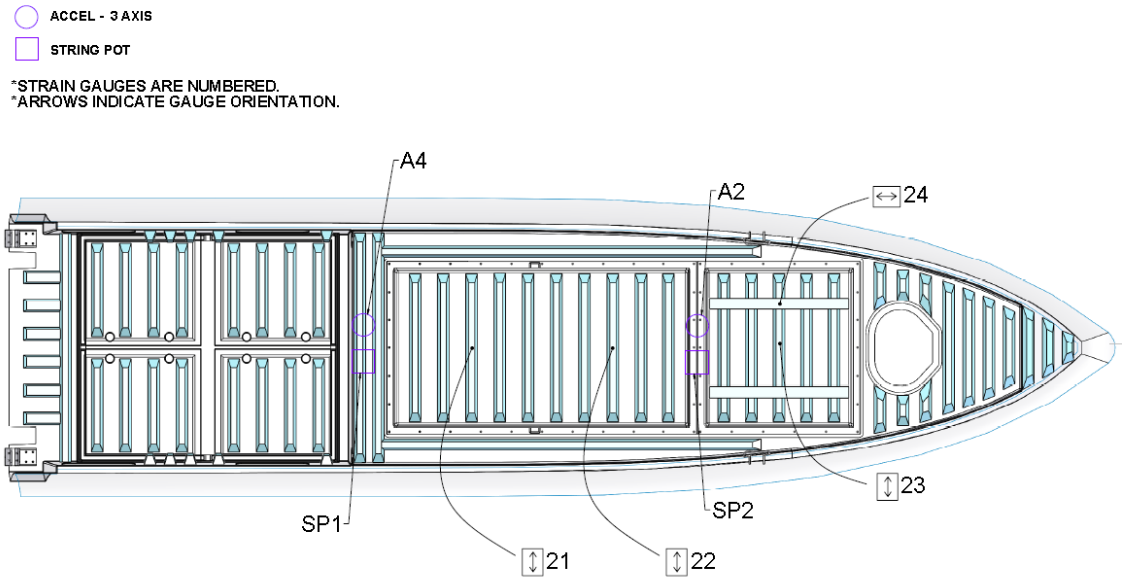


Figure 134 - Accelerometer, String Pot and Hatch strain gauge locations for the 11M prototype

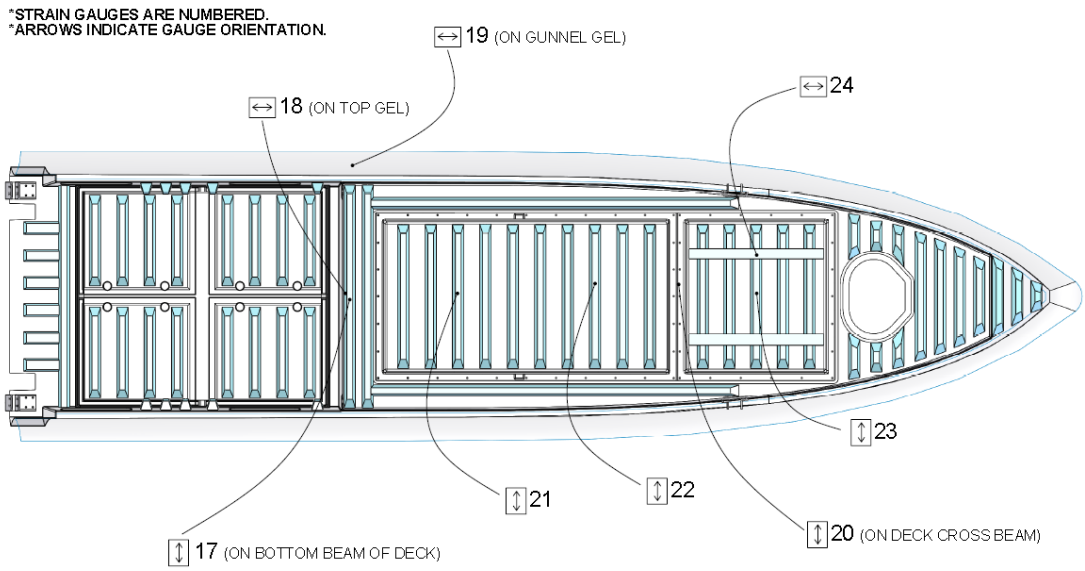


Figure 135 - Deck Strain Gauge locations for the 11M prototype

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Six (6) accelerometers were installed in the 11M prototype. Two of these, designated A1 and A5, were located at the approximate LCG of the craft. A1 is a 25g range accelerometer and A5 is a 10g range accelerometer. The redundancy was due to prior issues experienced with accelerometer A1 during evaluations of the 850B. After reviewing this test data it does appear that A1 does have an issue perhaps due to submergence, so A5 was used when processing the drop test data. Forward and aft accelerometer placement are shown in figures 136-137.



Figure 136 - Forward Accelerometer placement 11M



Figure 137 - Aft Accelerometer placement 11M

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5.6.6 11M Prototype Drop Testing Results

Sampling rate during drop testing was increased to 500 Hz. This was done to better capture the drop event and at the recommendation of CCD based on a review of the 850B test data. The 11M prototype was lifted using the installed lift hardware to a single point. This ring was placed into the release device which was activated by air pressure. The boat was suspended using a travel lift and dropped into calm water.



Figure 138 - 11M prototype prior to adding deck ballast

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Figure 139 - 11M prototyoe undergoing drop testing

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Figure 140 - Drop test 11M Prototype

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Figures 139-140 above show the drop testing. The 11M prototype was drop tested three times at 15,800 lbs. After the first event, damage to the deck in the area of the hatch flanges was evident. Two more drops were performed, and the damage to the deck progressed. During each event water came over the stern; also the impacts damaged some of the water bags on deck. After 3 drops testing was terminated, as the aft and mid deck hatches got pushed into the hull cavity due to failure of the deck flanging.

Inspections at the time of this report indicate that the hull did not suffer significant damage. Damage was observed on the top of the engine compartment on the aft port side due to buckling that occurred as the boat was being lifted after the third impact.

A lot of water was observed in the engine compartment; this was due to a combination of water coming in over the top of the engine cover and the forward water bags leaking. The drop event is severe, and it was noted that the lead weights crushed the ¾ inch plywood placed on the hull framing as a result of the impacts. Lag bolts holding some of the lead ripped out of the wood. Figures 141-146 show the damage in the different areas.

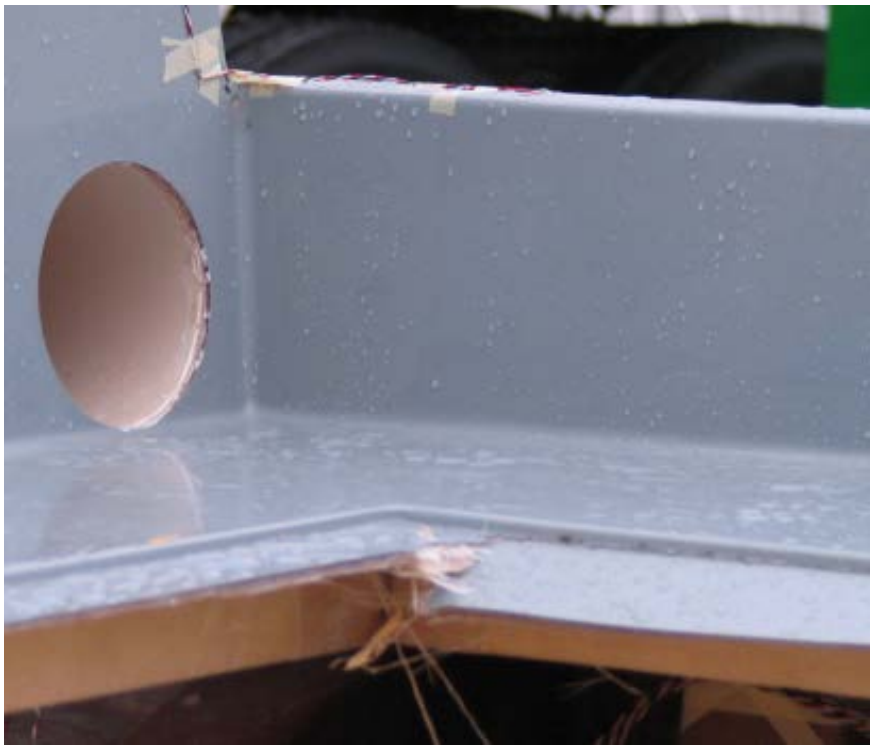


Figure 141 - Flange damage near the engine compartment

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Figure 142 - Port Aft Engine Compartment Showing Damage



Figure 143 - Deck Flange showing damage due to fastener (temporary screw holding deck)

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Figure 144 - Deck Drain to engine compartment showing some separation



Figure 145 - Damage to deck flange where an aluminum cross member sits

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Figure 146 - Damage to mid Deck cross beam where it meets longitudinal

5.6.7 11M Prototype Drop Test Data

The DAC system was activated for each drop event. Data was collected and analyzed for three drop events. The processed data from the first drop is presented below (figures 147-148). Subsequent drops 2 and 3 are in provided in Appendix R to this report.

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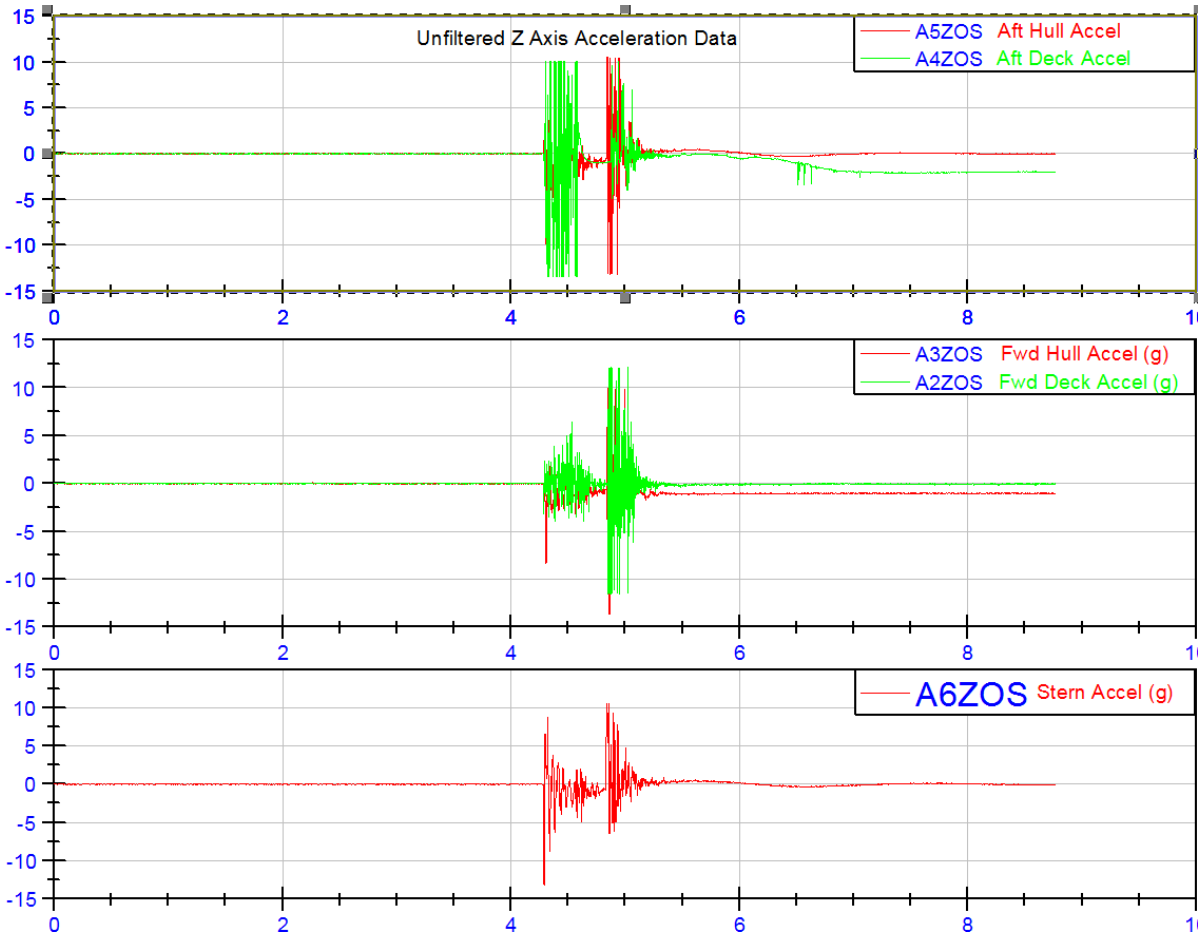


Figure 147 - Unfiltered Vertical Axis Acceleration data (g), Drop 1, 11M Prototype

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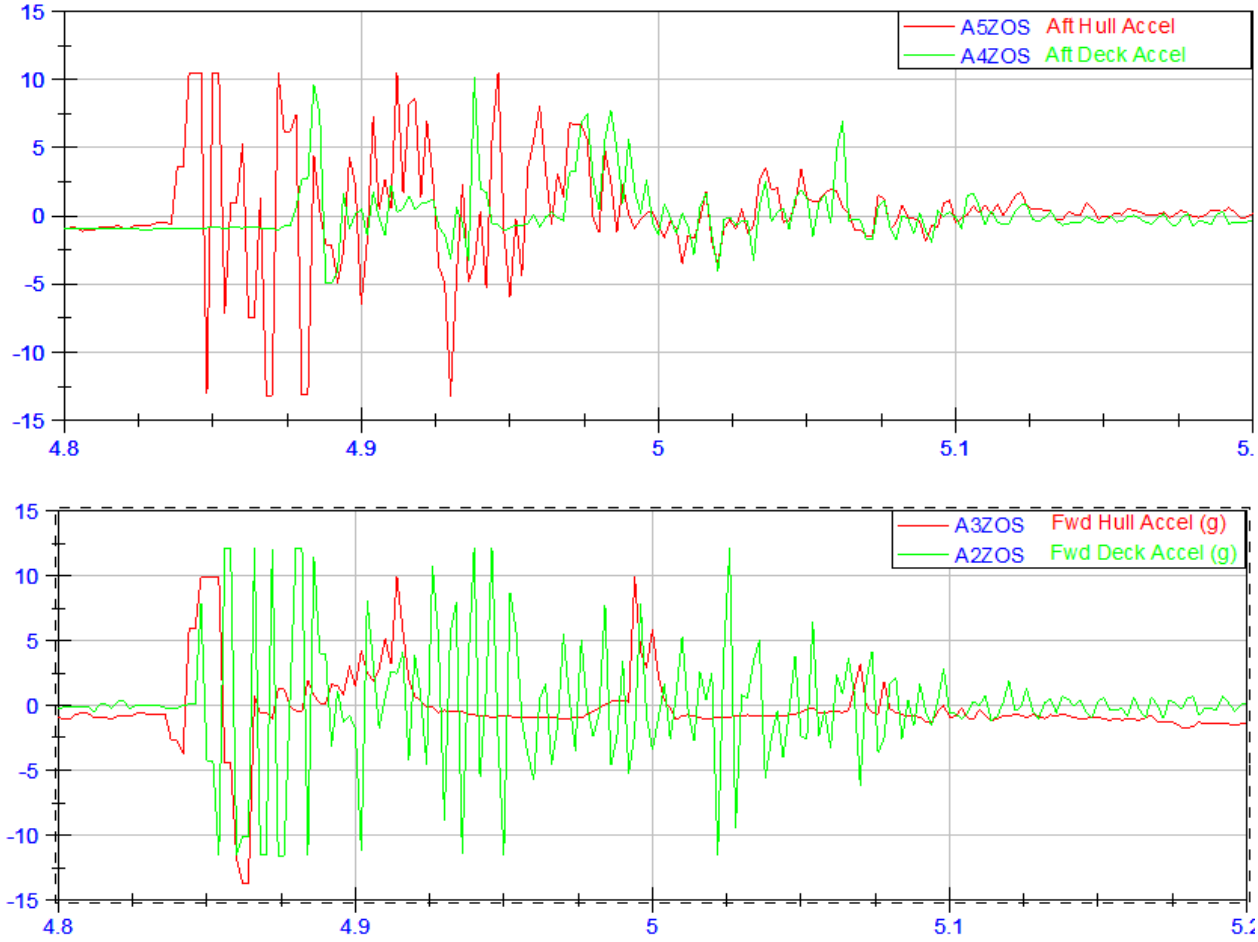


Figure 148 - Vertical Acceleration Data (g) Slam event, 11M Drop 1

Vertical acceleration data indicates that the limits of the 10g accelerometer were reached. The hull and deck appear to have very different responses as indicated by the slam event view. It is possible that the deck became excited by the force of the sling system impacting the deck. Accelerometer 3 was found to be detached after testing. The acceleration data indicates this occurred on the first drop. Therefore, A3 data should be disregarded for drops 2 and 3.

An FFT plot of the acceleration data is presented below (figure 149). The event is short and not repeating like slam events during ocean testing, so it is difficult to determine the natural frequency of the hull and deck from this data.

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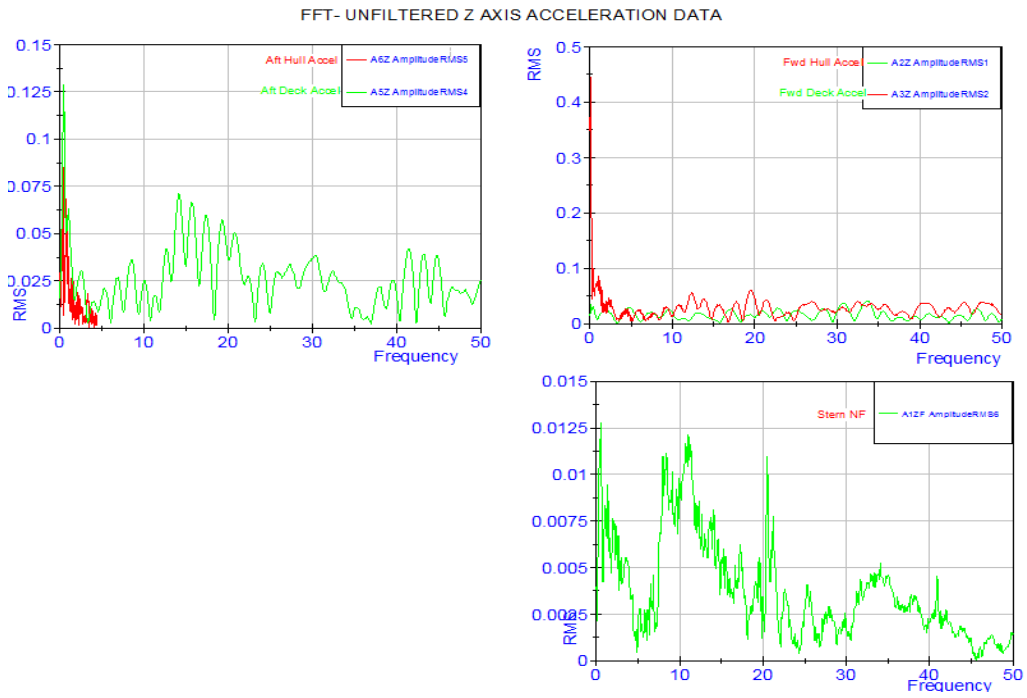


Figure 149 - FFT of Vertical Acceleration Data, Drop 1, 11M

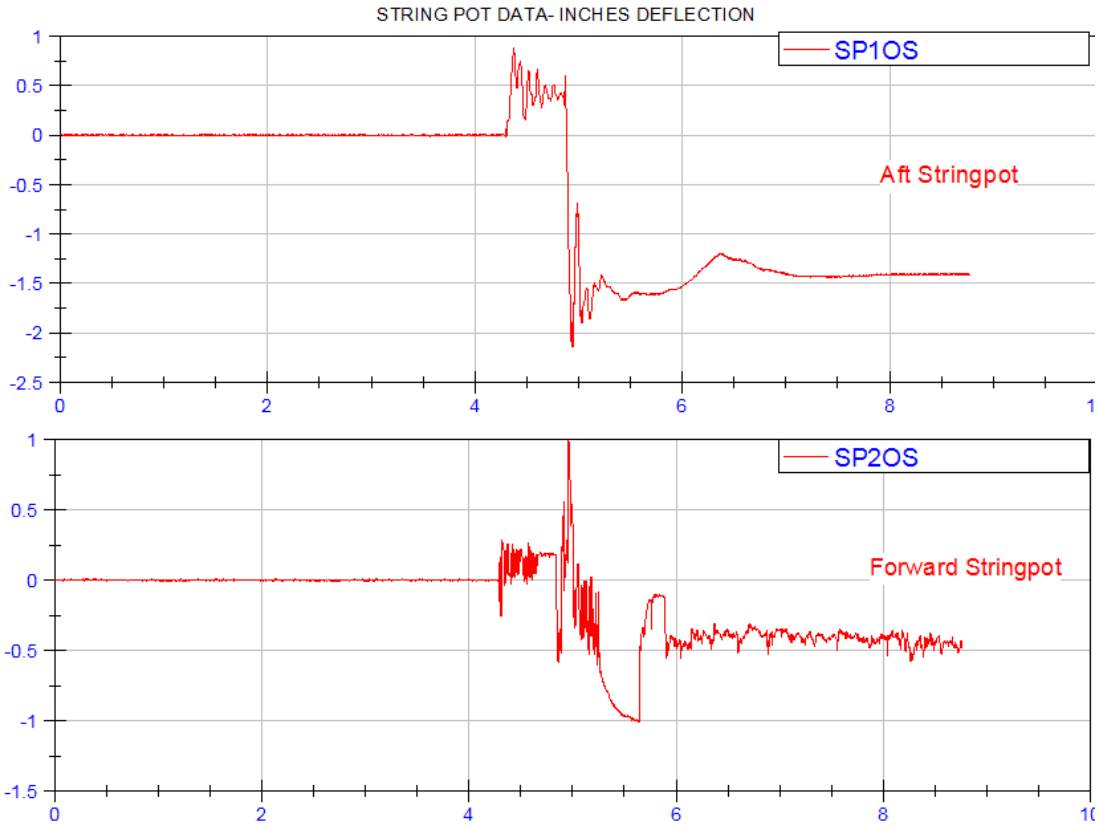


Figure 150 - String Pot Data, Drop 1, 11M

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The string pot data above (figure 150) indicates significant hull to deck movement. SP2 was connected to the deck beam that received damage so the offset is logical. The offset from start to finish gives an indication of the hull to deck deflection when suspended and in the water under ballast load conditions. SP1 which is the aft deflection indicates about 1.5 inches of static load deflection and about the same for the dynamic deflection. SP2 the forward string pot shows less of a static deflection and more dynamic deflection.

Below are the strain data from the first drop event (figures 151-153).

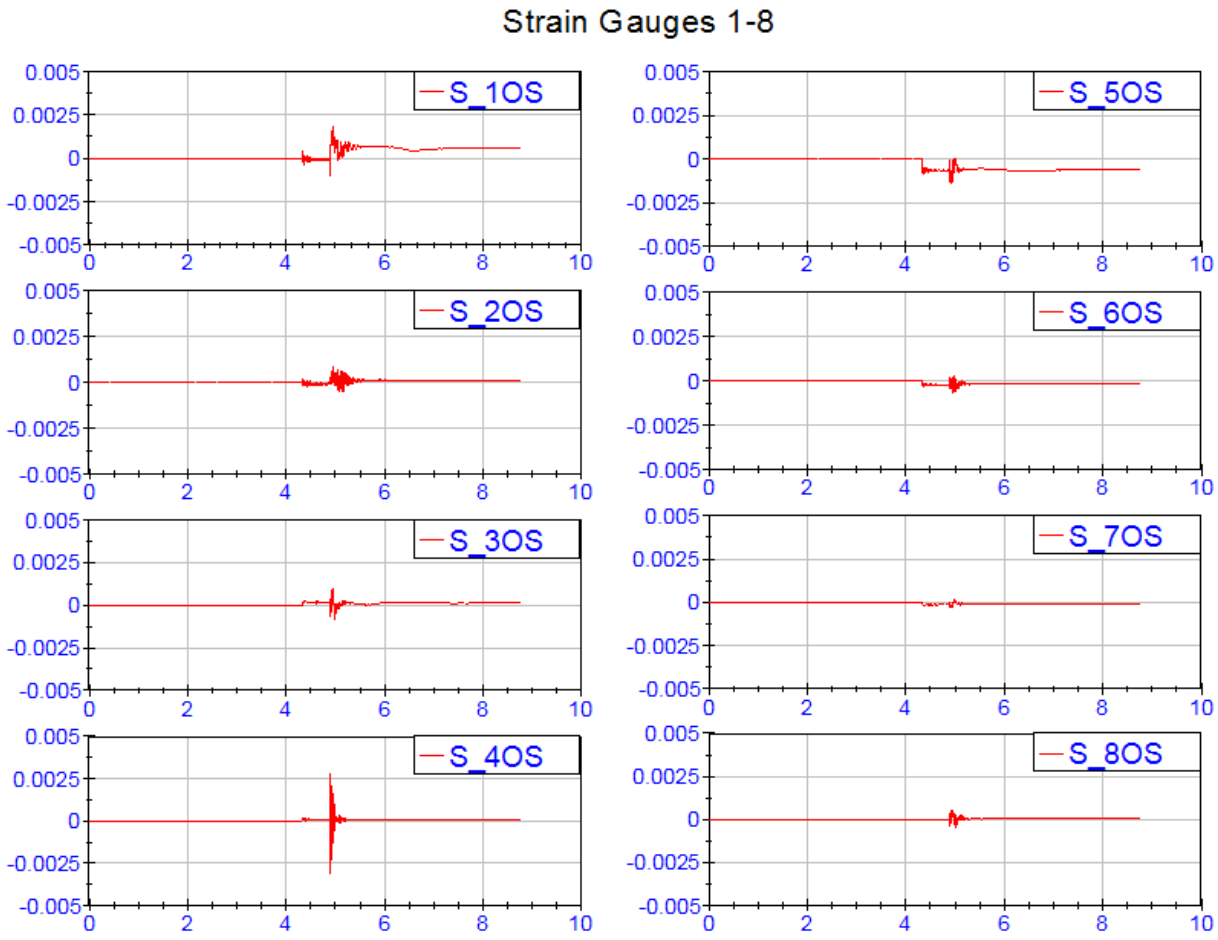


Figure 151 - Data from Strain Gauges 1-8, Drop 1, 11M

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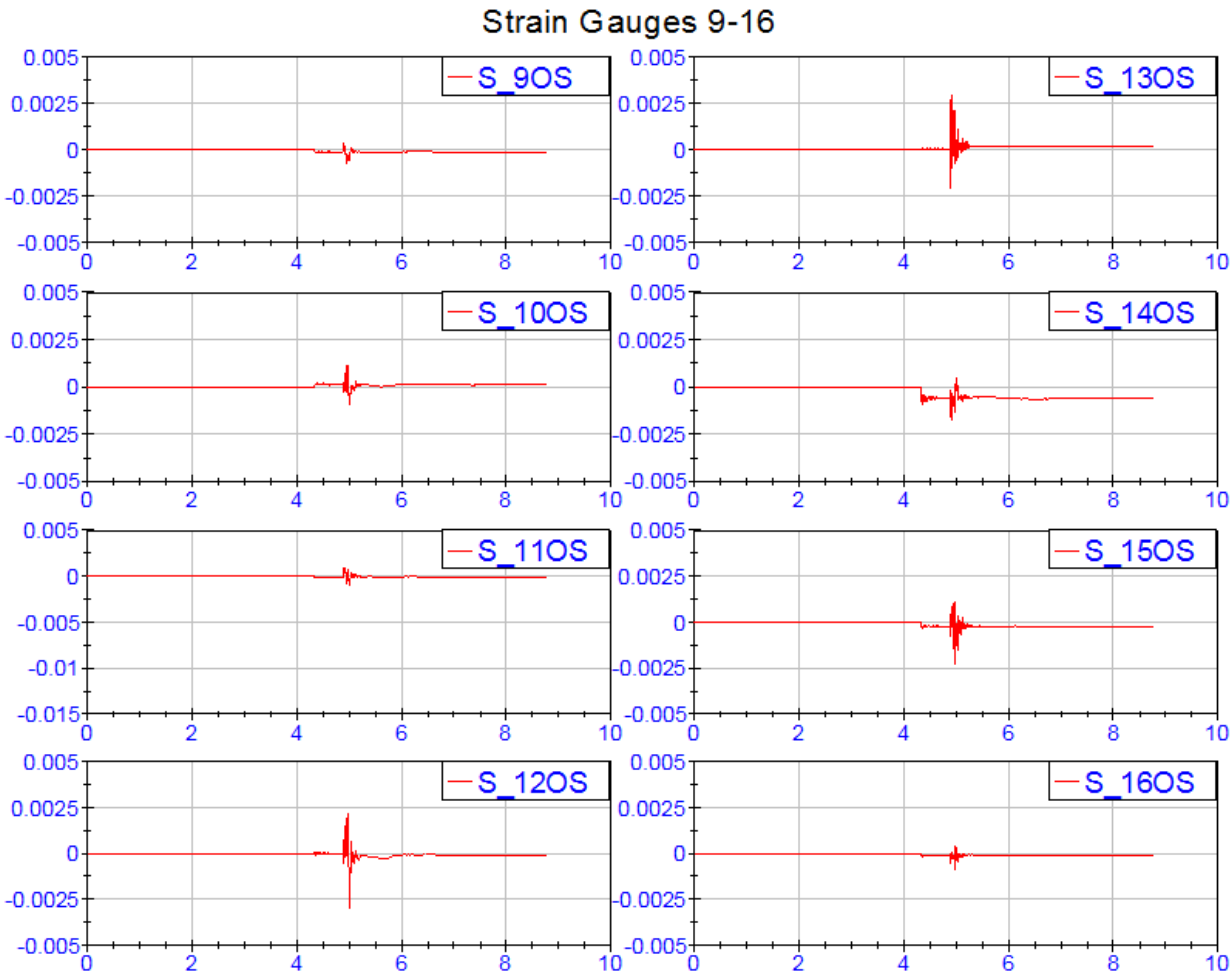


Figure 152 - Strain Data Gauges 9-16, Drop 1, 11M

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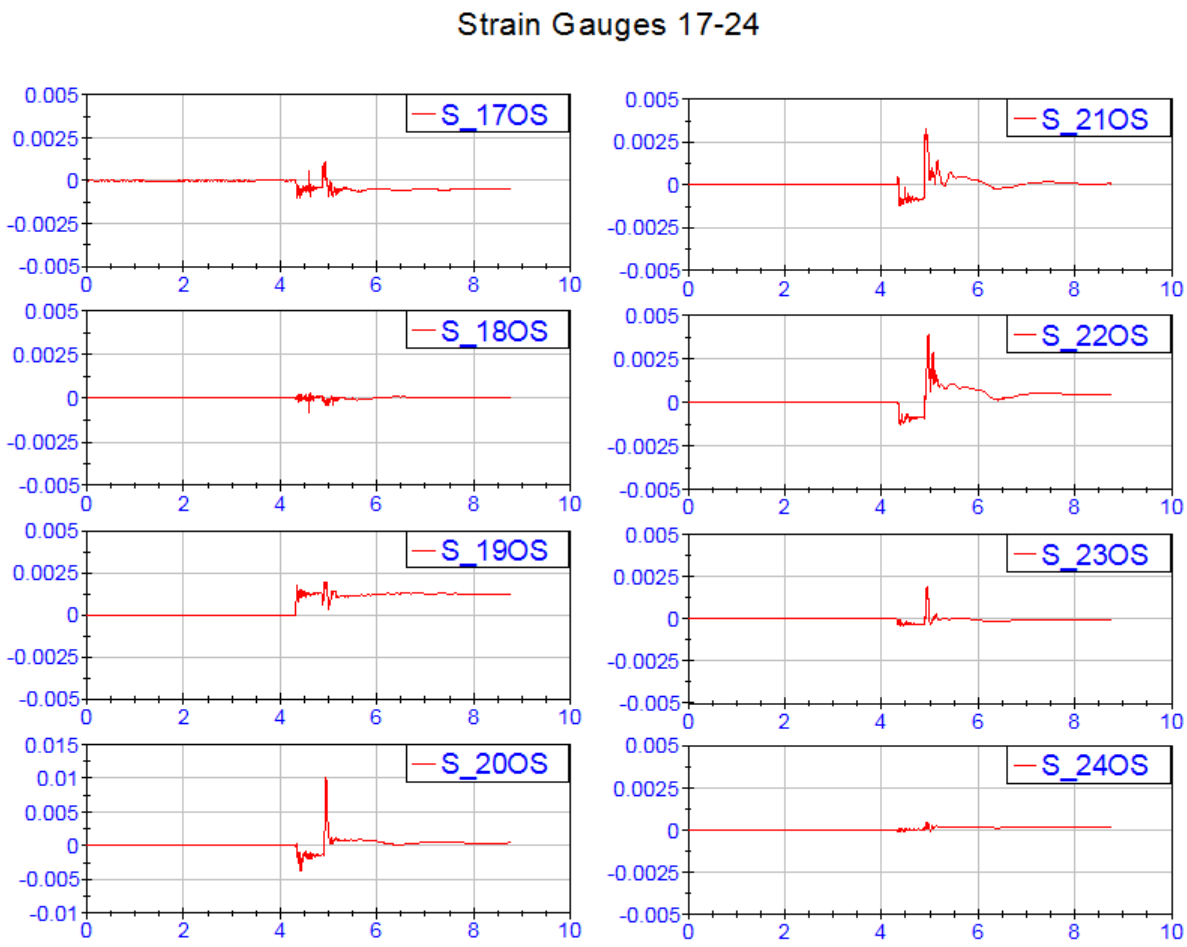


Figure 153 - Strain Data Gauges 17-24, Drop 1, 11M

Strain data indicates that hull strains were low. The highest strains were observed at strain gauge 20 which is located on a transverse deck frame between two hatches. This beam did have a failure where it intersected a longitudinal deck beam. The area of the strain gauge was undamaged.

5.6.8 11M Prototype Drop Testing - Conclusions

The damage to the deck in the area of the hatches indicates the structure is inadequate in this area. The deck flange needs additional thickness and support. Note that the deck hatches were only temporarily screwed to the deck and screws were only placed in the corners. Even with this it is clear that additional deck support is needed for hatches.

The transom of the craft may need to have increased stiffness, and the sidewall of the engine compartment in the area of the aft lift points may need additional reinforcement. This is indicated by the sidewall buckling that was observed when pulling the boat with a flooded engine compartment.

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No issues were observed on the forward lift points and no issues were observed with the hull structure.

The hatches appeared to be overbuilt. They did not show signs of severe damage and depending on the repair selected they can be reused.

5.6.9 11M Prototype Summary

The 11M prototype was significantly lighter than the baseline craft. Drop testing of the craft revealed that the deck support for the hatches is inadequate. The problem is similar to that observed and reworked on the 850B but is exacerbated by the larger deck area between the edge of the tub deck and the hatch flanges. Three rework options are recommended for consideration. One option is to increase the hatch flanges, and provide additional deck support through the use of gussets that extend from the transverse framing. Another option would be to cut the deck close to the tub return and build a new larger hatch. A third option is to incorporate full height bulkheads similar to those used in the 850A design. This option would make a much more rigid hull to deck connection which would impact the ability of the deck to mitigate shock loads.

It is recommended that CCD evaluate the 850B suspended deck and make a value determination as to the benefit of this concept prior to modification of the 11M prototype. Depending on the modification selected, it will have some weight impact. The full width deck would have the least impact with little weight increase.

Examination of the strain data collected in the drop test vs. the predictions of the FEA show that they are of the same magnitude. The drop test was a large area slam, and the FEA runs for the 11M were small area slams. Also, the FEA model is a static analysis vs. the drop test which is a dynamic event. Once the 11M prototype is completed and sea trails occur, further assessments as to the modeling method can be made.

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6.0 Benefits Analysis

Following are the Metrics that were used to measure the success of the Lightweight Shock Mitigating Boat Manufacturing Innovation Program along with the results obtained:

Table 24. Metrics for Measuring Program Success.

Criteria/Description	Baseline	Goal	Results
Hull & Deck Weight	8.5m A – 2509 lb 8.5m B – 2509 lb 11m – 2275 lb hull 11m- 3100 lbs bonded hull and deck.	10% 15-20% 15-20% Reduction	8.5m-A- 1665 lb – 34%(design only) 8.5m-B- 1509 lb- 40% As Built 11m- hull-1295lb- 43% weight 11m- 2100 lb bonded hull and deck 37% weight savings.
Shock Mitigation/Maximum G Load	5-7 G Peek	25% Reduction in Peek G loads	Testing indicates 30%-50%+ vertical peak G reduction (FFT-RMS) between hull and deck at LCG. Similar reduction between hull and deck at the helm station were observed.
Impact Resistance Hull Deflection	Current GRP Laminate- Rigid Body Construction	30% Increase in Laminate deflection – Non-Rigid Body	Hull to Deck deflection data indicates non-rigid body condition in 8.5m prototype. Hull to deck deflections measure 1.2 inches under high wave impacts.

7.0 Implementation Status

Implementation will be on the hull and deck components of two specific Rigid Inflatable Boat Platforms, the 8.5m and the 11m RIB. The US Navy's Small Boats Program Office, PM 325G, purchases all small boats using Government Services Administration (GSA) Federal Supply Schedules. The Program Office works closely with the Naval Surface Warfare Center Carderock Combatant Craft Division (NSWCC CCD) to develop performance specifications for these craft.

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Mr. Jason Marshall, NSWCC CCD 231, was the point of contact for the original SBIR design development and was the lead TOPC on this project. This helps to ensure the developed technology will be incorporated into future 8.5m and 11m RIB performance specifications. This will set a new standard for small craft performance and establish a clear transition path for technology implementation.

The 8.5m craft is targeted as a replacement craft for the Ready Boat on DDG-51. Significant weight reduction was achieved; the 8.5m prototype craft is lighter than today's 7m craft. NAVSEA Combatant Craft Division completed a DDG-51 Class VBSS Feasibility Study in August 2010 (document number N0002410WX30891), sponsored by the US Navy Boats and Craft Program Office. PEO SHIPS, PMS 325G, funded the effort in FY10. The study noted that the onboard 7m RIB is not capable of deploying a SOF team needed to complete VBSS level II missions. VBSS level III missions, previously owned by NECC Maritime Expeditionary Security Force (MESF) cannot be performed by the surface fleet which is currently only trained to Level II VBSS. The report stated that a NSW capable small craft is needed on widely distributed surface fleet assets to address SOF/VBSS Level III missions and identified a modified 8.5m RIB as a potential replacement for the current 7m RIB.

The study identified the new lightweight and shock mitigating technology as having the potential to reduce structural weight so that an 8.5m RIB can replace the 7m currently deployed on ships such as DDG-51. The 8.5m prototype from this project has been delivered to the Navy and is one of four boats being evaluated as the Navy's Next Generation 7m RIB. If selected, it will provide the Navy with a much more capable and higher performance craft.

The 11m craft weight savings were also very compelling. Significant weight savings were demonstrated using the advanced designs, one with fiberglass reinforcement and the other with an Innegra/Carbon hull laminate. The prototype was fabricated with the lower cost, lower risk fiberglass design. The weight saving and performance benefits of the prototype craft indicate that a single 11m craft can be designed to meet the mission needs of three different craft today. An 11m Multifunctional Craft (MFC) could replace 11m ready boats, 11m EOD boats and 11m Over The Horizon (OTH) craft with a single more capable platform.

The Combatant Craft Division (CCD) supports the U.S. Navy, Army, Marine Corps, Naval Special Warfare, Air Force, Coast Guard and other DoD and non-DoD activities including private industry. CCD leverages boat and craft lessons learned across the DoD community and works collaboratively to transfer technology and combine resources and improve efficiency. As a Joint Service Provider (JSP), CCD is the DoD boat and watercraft authority. Technology developed under this program is applicable to Navy composite boats. Composite boats represent one half of the current 3,000 units of the small craft inventory. In addition to the targeted platforms, the technology can be directly applied to 5 m, 7 m and 9 m RIBs, utility boats and harbor patrol boats.

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7.1 Industrial Base

The intent of this program was to develop manufacturing technology that will be broadly disseminated across the current marine industrial base. The industrial base provides boats to the Government through the GSA contracting system in response to government provided performance specifications. Once developed and incorporated into the performance craft specifications, the technology can be quickly deployed to multiple platforms and the boat builder community.

Two leading RIB platform suppliers are members of the project team; Brunswick Commercial Products (8.5m RIB) and Zodiac Hurricane Technology (11m RIB). The developed technology has been directly inserted at the two OEM RIB manufacturers providing the Navy rapid access to this significant manufacturing improvement.

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APPENDIX

Program: IBIF
Panel Identification: 850A Hull
Hand Layup
AOC K022-CCK-18
Vectorply E-LTM 3610 (3 plies, 0/90/0/90/0/90)

Property	**Value**
ASTM D3039 Tensile Strength, 0°	38.9 ksi
ASTM D3039 Tensile Modulus, 0°	2.01 msi
ASTM D6641 Compressive Strength, 0°	41.2 ksi
ASTM D6641 Compressive Modulus, 0°	2.39 msi
ASTM D790 Flexural Strength, 0°	59.1 ksi
ASTM D790 Flexural Modulus, 0°	1.46 msi
ASTM D790 Flexural Strength, 0°, at 120°F	50.9 ksi
ASTM D790 Flexural Modulus, 0°, at 120°F	1.31 msi
ASTM D790 Flexural Strength, 0°, at 150°F	42.6 ksi
ASTM D790 Flexural Modulus, 0°, at 150°F	1.14 msi
ASTM D790 Flexural Strength, 0°, at 175°F	44.1 ksi
ASTM D790 Flexural Modulus, 0°, at 175°F	1.21 msi
ASTM D2344 Short-Beam Shear Strength, 0°	5.42 ksi
ASTM D256 Impact Strength, Unnotched, 0°	26.8 ft-lb/in
ASTM D2584 Resin Content	51.0 % by weight
ASTM D2584 Glass Content	49.0 % by weight
ASTM D792 Laminate Density	1.79 g/cm^3
ASTM D2734 Void Content	1.3 % by volume
Laminated Thickness Per Ply	0.080 in.

Table 1: Mechanical & Physical Properties
Note – all values represent ambient lab conditions, unless otherwise noted.

Program: IBIF
Panel Identification: 850B Hull
Resin Infusion
AOC K022-EBB-00
Vectorply E-LTM 3610 (3 plies, 0/90/0/90/0/90)

Property	**Value**
ASTM D3039 Tensile Strength, 0°	44.7 ksi
ASTM D3039 Tensile Modulus, 0°	2.41 msi
ASTM D6641 Compressive Strength, 0°	47.0 ksi
ASTM D6641 Compressive Modulus, 0°	3.66 msi
ASTM D790 Flexural Strength, 0°	84.6 ksi
ASTM D790 Flexural Modulus, 0°	2.57 msi
ASTM D790 Flexural Strength, 0°, at 120°F	68.1 ksi
ASTM D790 Flexural Modulus, 0°, at 120°F	1.64 msi
ASTM D790 Flexural Strength, 0°, at 150°F	58.0 ksi
ASTM D790 Flexural Modulus, 0°, at 150°F	2.04 msi
ASTM D790 Flexural Strength, 0°, at 175°F	65.3 ksi
ASTM D790 Flexural Modulus, 0°, at 175°F	1.62 msi
ASTM D790 Flexural Strength, 90°	84.1 ksi
ASTM D790 Flexural Modulus, 90°	2.42 msi
ASTM D790 Flexural Strength, 90°, at 120°F	69.8 ksi
ASTM D790 Flexural Modulus, 90°, at 120°F	2.01 msi
ASTM D790 Flexural Strength, 90°, at 150°F	54.1 ksi
ASTM D790 Flexural Modulus, 90°, at 150°F	1.83 msi
ASTM D790 Flexural Strength, 90°, at 175°F	61.4 ksi
ASTM D790 Flexural Modulus, 90°, at 175°F	1.48 msi
ASTM D2344 Short-Beam Shear Strength, 0°	5.83 ksi
ASTM D256 Impact Strength, Unnotched, 0°	34.0 ft-lb/in
ASTM D2584 Resin Content	34.4 % by weight
ASTM D2584 Glass Content	65.6 % by weight

ASTM D792 Laminate Density	1.84 g/cm^3
ASTM D2734 Void Content	0.9 % by volume
Laminated Thickness Per Ply	0.049 in.

Table 1: Mechanical & Physical Properties
Note – all values represent ambient lab conditions, unless otherwise noted.

October 19, 2011

Danna Kelley
Senior Program Manager
Advanced Technology International
91 Technology Blvd., Suite 200
Anderson, SC 29625

Program: Contract No. SP4701-10-C-0028, "Deployment of Lightweight Shock Mitigating Boat Manufacturing Innovation"
Letter Subcontract Number 2011-510

Subject: Creep Test Results – E-Glass Panel

Dear Ms. Kelley,

We have completed ambient, 120°F, 150°, and 165°-170°F creep testing on an E-Glass/FR vinyl ester panel, described as the 850B design in the test plan. The loading scheme is also contained in the test plan document. The test panel supporting fixture was modified so as to provide a base for the stiffening beams all the way through the sides of the support structure (see Figure 1).

The panel was bolted down to the test frame on 3 sides. The 4th side was supported, but not fixed. The deflection indicator was zeroed, and load was applied with weights, supported on a beam of 4" width by 74" length.

The initial deflection was noted. The deflection was then recorded after 24 hours, 48 hours, and 72 hours. After 72 hours, the weight was removed. Residual deflection was noted, and was recorded again 24 hours after removal of weight.

The same panel was tested under ambient conditions, then re-tested at the higher temperatures. The applied load was 2400 pounds, distributed evenly along the length of the loading beam.

The results were as shown:

Test Temperature	**Ambient (mid 80°'s F)**	**120°F**	**150°F**	**165°-170°F**
Initial Deflection Under Load	0.187"	0.190"	0.191"	0.182"
Deflection Under Load at 24 Hours	0.195"	0.218"	0.222"	0.200"
Deflection Under Load at 48 Hours	0.198"	0.223"	0.230"	0.232"
Deflection Under Load at 72 Hours	0.200"	0.228"	0.241"	0.233"
Deflection After Weights Removed (immediate)	0.112"	0.113"	0.079"	0.090"
Deflection 24 Hours After Weights Removed	0.069"	0.088"	0.049"	0.042"

The permanent set after all of the testing was approximately 3/16", at the lowest point.

Please do not hesitate to contact us should you have any questions regarding these test results.

Sincerely,

Art Wolfe
Structural Composites Inc.



Figure 1 – Test Fixture Side, Showing Support Under Beams



Figure 2 - Deflection Indicator

April 27, 2011

Customer: Advanced Technology Institute
91 Technology Dr., Suite 200
Anderson, SC 29625

Attention: Ms. Danna Kelley-Haddad

Subject: Resin Infusion Study
BAA #0001-10
Subcontract 2011-510

Program: Deployment of Lightweight Shock Mitigating Boat Manufacturing

Title: **AOC KO22-EBB-00 Infusion Resin Workability Study**

Objective

Determine the feasibility of using a resin infusion process for fabrication of the 850B and 11M boats.

Background

AOC K022-EBB-00 resin is an unpromoted fire retardant resin being evaluated for use in the construction of the 8.5m and 11m RHIB. Upon receipt of the resin a series of tests were performed to evaluate the suitability of the resin for the project. This report examines the methods to determine the suitability of the resin for use for this project

Gel Time Tests

To achieve various gel times, AOC's product literature lists various combinations of 12% Colbalt, DMA, and 2,4 Pentanedione. For the initial tests, the resin was promoted with 12% Cobalt and no additional additives. Table 1 below shows the results of the gel tests used a promotion level of 0.1% - 12 percent cobalt and highpoint 90 catalyst.

Table 1: Gel Time Results (0.1% - 12 percent cobalt)

Resin	Catalyst Used	% Catalyst	Shop Temp (^{o}F)	Gel Time (mins)
AOC KO22-EBB-00	HP 90 Red	1.00	70	105
AOC KO22-EBB-00	HP 90 Red	1.25	70	75
AOC KO22-EBB-00	HP 90 Red	1.50	70	55

Also attached is the AOC product literature provided by AOC with additional information of the resin properties and various promotion combinations.

Panel Infusion

To determine materials properties and evaluate the resin's performance in surface infusion, a 50" x 50" test panel was fabricated. Three plies of Vectorply E-LTM 3610 fabric were infused on a flat table. This laminate schedule was chosen as it represents the anticipated structural hull laminate for the 850B design. One ply of Enkafusion 7001 was used as the primary surface infusion media and runs the width of the panel and stops 10: short of the panel's end. The 7001 was feed along one edge of the panel by a 50" length of Enkadrain 100. Figure 1 on the right shows the panel during infusion. The resin front was tracked to determine the flow rate of the resin. Table 2 shows the results of the resin flow.

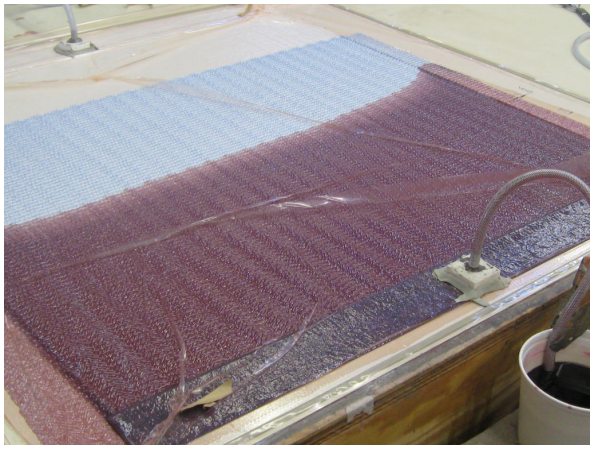


Figure 1: Infusion of test panel

Table 1: Panel Infusion Rate

Time (mins)	Distance (in)	Notes
5	16.5	
10	25	
15	30.5	
20	34.5	End of 7001

Infusion Media Evaluation

The effects of different surface infusion media have also been evaluated. Using the same laminate schedule as above, three 10" x 50" panels were infused using different infusion media. Flow rate and quantities of excess (waste) resin entrapped in the infusion media were determined. Figure 2 below shows the set up of the three panels under the same bag.. The infusion media as follows; left – one ply Enkafusion 7001; middle – two plies Enkafusion 7001; right- One ply Enkafusion 8004 Figure 3 shows the progress of the infusion at the 2 minute mark. Note that the 8004 on the right had already reached the end of the infusion media in one minute.

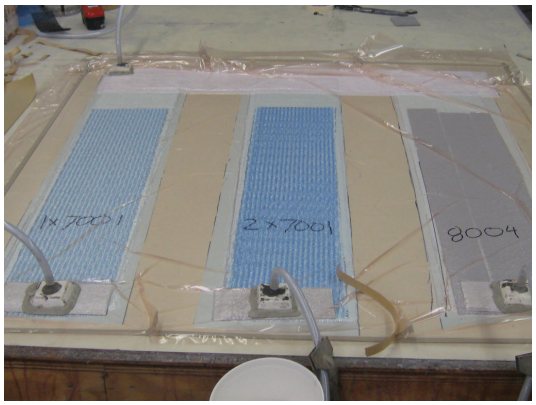


Figure 2: Test Set-up

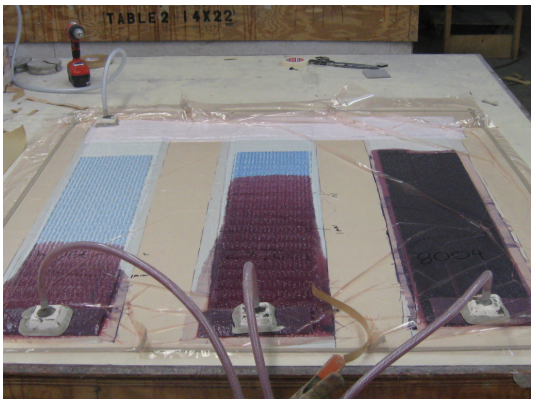


Figure 3: Infusion @ 2 mins

Tables 3 and 4 show the results of the flow rate test and the amount of waste resin based on the type of infusion media used. Waste resin was determined by carefully removing a section of the infusion media with the resin after cure and weighing it to determine the weight of resin per square foot. Note that the weight of the infusion media represents less then 5% of the overall weight and was therefore not subtracted from the total weight of the resin weight.

Table 2: Infusion rate comparison

Time (mins)	Distance (in)		
	One Ply 7001	Two Plies 7002	One Ply 8004
1	8	17	36
2	12.5	26	**End of Media**
3	15.5	32.5	
4	18	38	
5	20	**End of Media**	

Table 3: Waste resin by infusion media type

Infusion Media	Resin Weight in Media
	(lbs /sq ft)
One Ply 7001	0.129
Two Plies 7002	0.391
One Ply 8004	0.677

Comparison to SBIR Phase II Resin System

The resin which will be used for the SBIR Phase II program is Interplastic product code CORVE 8106. A comparison of infusion characteristics is shown:

Viscosity: AOC K022-EBB-00 225 centipoise
Interplastic CORVE 8106 175-250 centipoise

Wet-Out Rate During Infusion:
Laminate – 3 plies 3610 0/90 w.CSM
Surface Infusion Medium – 1 x 7001

Wet-Out Distance at 5 minutes, 28” Hg:

AOC K022-EBB-00 20 inches
Interplastic CORVE 8106 18 inches

Lightweight Shock Mitigation in Naval RIB Hull Structures

SCRA Subcontract #2011-510

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850A and 850 B Requirements and Inputs
2 March 2011

850 A Boat

- Lightweight Low Risk EOD Boat
- Group 100- Composite Items

* Time Permitting

850 A LIFT Analysis Inputs

- Lift – Boat and Trailer
  - Weight 13700 lbs
  - FOS Must be Greater than 6
  - 331.8” above Keel is lift point
- Lift- Boat only- full fuel
  - Weight 7240
  - FOS Must be Greater than 6
  - 335.2” above Keel is lift point

850 A Hull Analysis Inputs

- Hull
  - Fully loaded weight 11,000
  - Speed 30kts
  - ABS Pressure Calculations
  - 8 Panels Evaluated
  - Transom Analysis with Bracket

850 A Gun Analysis Inputs

- Height above upper deck 36 inches
- Load applied 1500 lbs

850 A EOD Summary

- placeholder

850 A Weight Breakdown

A BOAT	EOD					
Item			Weight	LCG	Notes	
Group	100					
		Hull	843		need LCG	
		Deck	568		need LCG	
		Console	350		need LCG	
	100 Total		1761			
Group	200		1198	-12.7	need adj for JP	
Group	300		495	126.4		
Group	400		151	147.4		
Group	500		25	196.8		
Group	600		1425	71.7		
			5055			

850 B Boat

- Prototype for the VBSS
- Group 100- Composite Items

Table 13. Comparison of Proposed DDG VBSS Craft with Current 7m RIB

		Current 7m RIB	DDG VBSS Craft
Length	*ft*	24	30
Beam	*ft*	9	9
Hoist Weight	*lb*	5600	5565
Full Load Weight	*lb*	7700	11000
Payload (excl. fuel)	*lb*	3200	5600/5900
Fuel Capacity	*gal*	35	180/140
Max Speed	*kts*	35	35
Speed, FL, 3' waves	*kts*	27	30
Engine Type		Inboard Diesel	Twin JP Outboards
Installed Power	*HP*	230	370
Interoperability		All DDGs	2 aboard DDG 52-78, 91-99,100; 1 aboard DDG 79-90, 99,101+ (plus 7m RIB)

* Time Permitting

850 B LIFT Analysis Inputs

- Lift
  - Weight 5600 lbs
  - FOS Must be Greater than 6
  - 7’ 4” (2235mm) above Keel is lift point

850 B Hull Analysis Inputs

- Hull
  - Fully loaded weight 13,100. This includes a 3000lb equipment load and 8 people with gear on board (285 lbs each).
  - Speed 30kts
  - ABS Pressure Calculations
  - 8 Panels Evaluated
  - Transom Analysis with no Bracket

850 B Gun Analysis Inputs

- Height above upper deck 36 inches
- Load applied 1500 lbs

850 B VBSS Summary

Table 12. VBSS Craft Longitudinal Center of Gravity Estimate

GROUP			WEIGHT	LCG	MOMENT
			(lb)	*(ft)*	*(lb ft)*
HULL			2160	12	25920
PROPULSION			1200	-1	-1200
ELECTRIC			150	2	300
COMMAND			100	22	2200
AUXILIARY			300	5	1500
OUTFIT			305	10	3050
ARMAMENT			0	0	0
Hoist Condition					
Fuel fwd	gal:	0	0	10	0
Fuel aft	gal:	50	348	3	1044
Coxswain			200	22	4400
PAX	no:	3	800	1	800
Total			5563	6.83	38014
Full Load Condition					
Fuel fwd	gal:	90	626	10	6264
Fuel aft	gal:	50	348	3	1044
Coxswain			200	22	4400
PAX	no:	19	5600	12	67200
					0
Total			10989	10.26	112751

850 B Group 100 Breakdown

B BOAT	VBSS					
Item			Weight	LCG	notes	
Group	100					
		Hull	734		need LCG	
		Deck	505		need LCG	
		Console	350		need LCG	
	100 Total		1589			
Group	200		1198	12.7	will change EOD	
Group	300		495	126.4	will change EOD	
Group	400		151	147.4	will change EOD	
Group	500		25	196.8	will change EOD	
Group	600		1425	71.7	will change EOD	
			4883			

GROUP 100 Limit is 2160 lbs

FEA Material Properties

Material	Ex	Ey (x10^6)	Max Strain	Notes
Polyester Mat	0.4	0.4	2%+	Fibers 100% strain
Glass Mat	1.0	1.0	2%	
E-Glass Unidirectional	5.0	1.0	2%	
Carbon Uni	13.0	1.0	1%	
Innegra	1.0	0.5	2%	Fibers 8%

Lightweight Shock Mitigation in Naval RIB Hull Structures

SCRA Subcontract #2011-510

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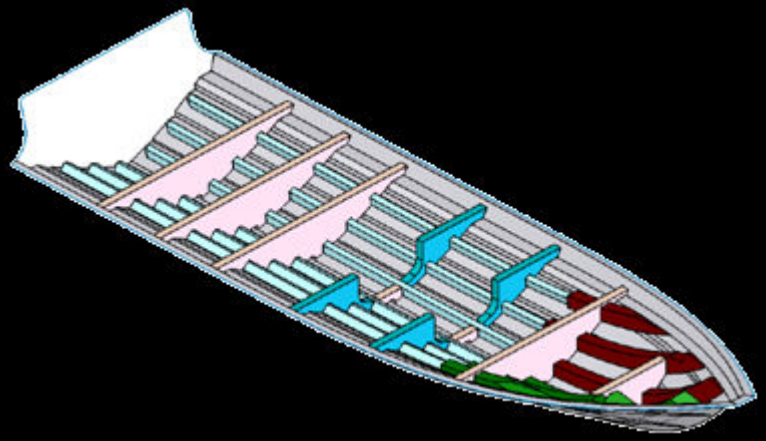
FINAL DESIGN REVIEW
April 2011

IBIF 850A Design Presentation

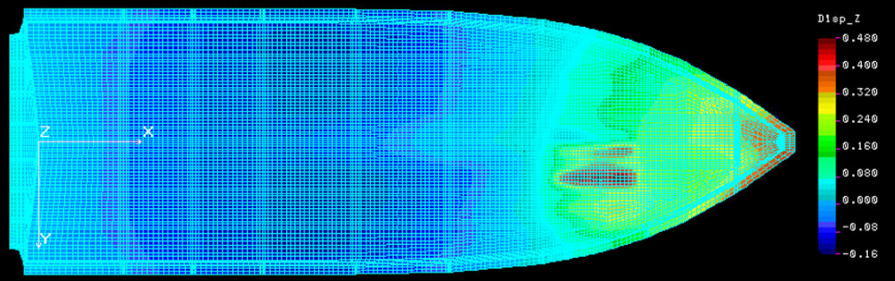
- Contents
  - 850A Rev 2 Design Presentation
  - Weight Estimates 850A, 850B
  - 850A Drawings Package
  - 850A FEA Load Cases

850A Design Presentation

- 850A REV 2 Drawing Package
  - Hull
  - Deck
  - Hatches
  - Tow/Lift/Console



- 850A REV 2 Structural Analysis
  - Wave Load FEA
  - Lift Load FEA



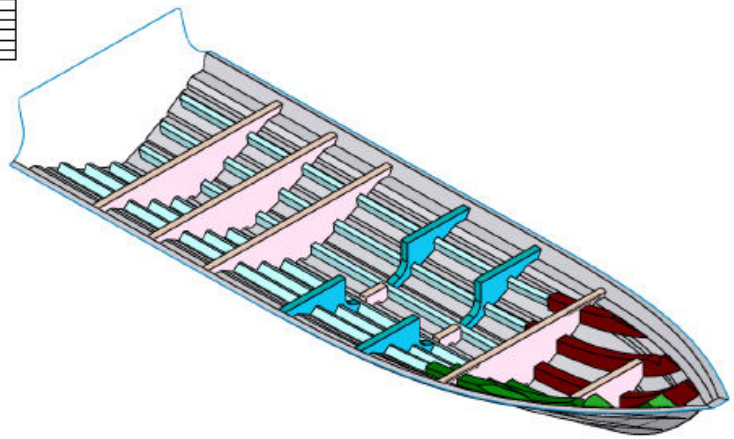
850A- Hull Drawings

BOM

ITEM NO.	QTY	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Grey	
2	A/R	AOC KUZ2-EBB-00 Resin	Alpha Owens Corning	KUZ2-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E-LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/- 45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/- 45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/- 45 fabric
9		not used			
10	A/R	E-LM T810 0 fabric - 3" wide	Vectorply	E-LM T810	0 fabric
11	A/R	3oz Chopped Strand Mat			
12	A/R	26lb Density Core	Acon baltek Corporation	PXC420	1-3/4" thick
13		not used			
14	90 LF	TR40S0A	Compsys	TR40S0A	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850MA-SPOS	
16	1	Starboard Mid Stringer	Compsys	BCG850MA-SPMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850MA-SPIS	
18	1	Port Outboard Stringer	Compsys	BCG850MA-PPOS	
19	1	Port Mid Stringer	Compsys	BCG850MA-PPMS	
20	1	Port Inboard Stringer	Compsys	BCG850MA-PPIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	1	Bulkhead A	Compsys	BCG850MA-BHA	
26	1	Bulkhead B	Compsys	BCG850MA-BHB	
27	2	Bulkhead C-D	Compsys	BCG850MA-BHCD	
28	3	Bulkhead E-F-G	Compsys	BCG850MA-BHE,F,G	
29	2	Bulkhead Wing C (P&S)	Compsys	BCG850MA-PSWC	
30	2	Bulkhead Wing D (P&S)	Compsys	BCG850MA-PSWD	
31	95 LF	FSz2010	Compsys	FSz2010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

STRUCTURAL COMPOSITES INC.
7705 TECHNOLOGY DRIVE
W. MELBOURNE, FL 32904-1576 (USA)

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DRAWING TITLE

850A HULL

DATE	4/7/2011
DRAWN	TED BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 850-850A-1 | SHEET 1 OF 5

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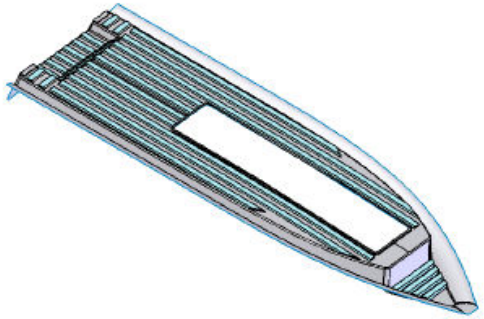
850A- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC KO22-EB8-00 Resin	Alpha Owens Corning	KO22-EB8-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 UNC fabric	Vectorply	E LTM 3610	U90 fabric
5		not used			
6		not used			
7	A/R	E-BXM 2406 +/- 45 fabric	Vectorply	E-BXM 2406	+/-45 fabric
8	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
9	130 LF	TR4010	Compsys	TR4010	
10	10 LF	TR3030X	Compsys	TR3030X	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



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DRAWING TITLE

850A DECK

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9000-850A-2 | SHEET 1 OF 3

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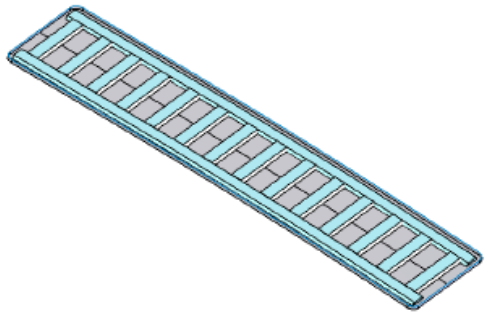
850A- Hatch Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC K022-EBB-00 Resin	Alpha Owens Corning	K022-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
6	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
14	50 LF	TR4010	Compsys	TR4010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



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3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850A HATCH

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9020-850A-0 | SHEET 1 OF 3

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850A – Laminate Schedule

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 3 x 3610
- Stringers – TR4030X /1810 / 1208 / 3608
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 3610 / 2408 / 1810 / TR4010 / TR3030X
- Deck Framing – Gel Coat / 2oz CSM / 4 x 3610 / TR4010 / TR3030X / 4 x 1810 / 2408
- Transom – Gel Coat / 2oz CSM / 2 x 3610 / 3oz CSM / 26lb Density Core / 3610

850A - FEA

- FEA Model of 850A Hull/Deck
- Applied Load to Hull Panels
- Deflection and Stress Reactions
- 10 Load Cases Total
  - Small Area Slamming (SAS)
    - Five Load Cases
      - 2 Aft and Fwd panels between bulkheads (Inboard and Outboard)
      - Included Stringer

850A- FEA

- Large Area Slam (LAS)
- Calm Water Planning (CWP)
- Boat Lift Points (BLP)
- Gun Mount
  - Longitudinal (GML)
  - Transverse (GMT)

850A- FEA Load Cases

Load Case	Load ID	Description	Pressure	Load
1	AMI	Aft Mid Inboard, SAS	10psi	--
2	AMO	Aft Mid Outboard, SAS	10psi	--
3	FI	Fwd Inboard, SAS	10psi	--
4	F0	Fwd Outboard, SAS	10psi	--
5	STR	Stringer, SAS	10psi	--
6	LAS	Large Area Slam	4.68psi	44,000lbs
7	CWP	Calm Water Planning	1.1psi	11,000lbs
8	BLP	Boat Lift Points	--	10,860lbs
9	GML	Gun Mount-Longitudinal	--	1500lbs
10	GMT	Gun Mount-Transverse	--	1500lbs

850A- FEA Analysis Overview











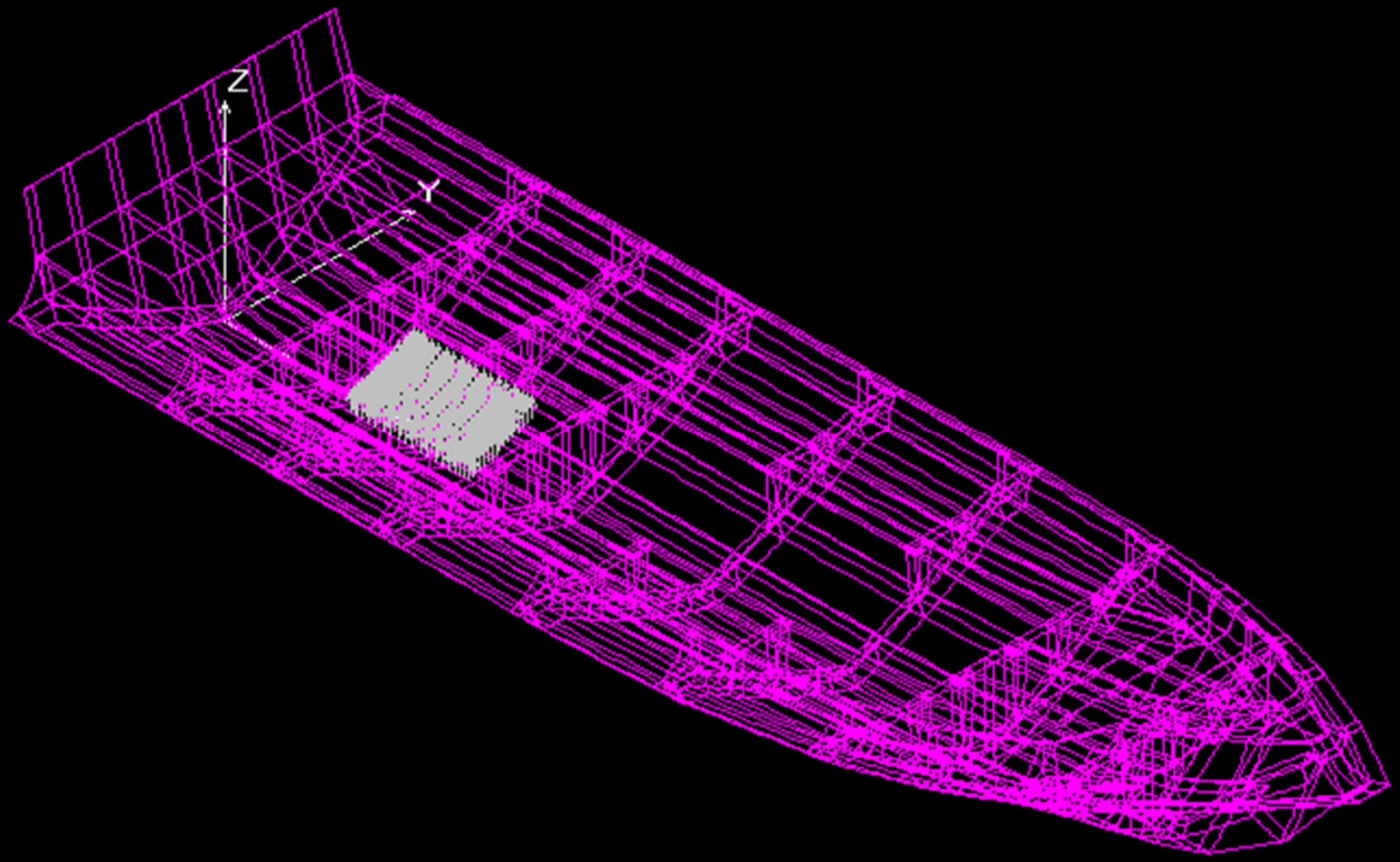
850A- FEA Analysis: Small Area Slamming (SAS)



Small Area Pressure Load

- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

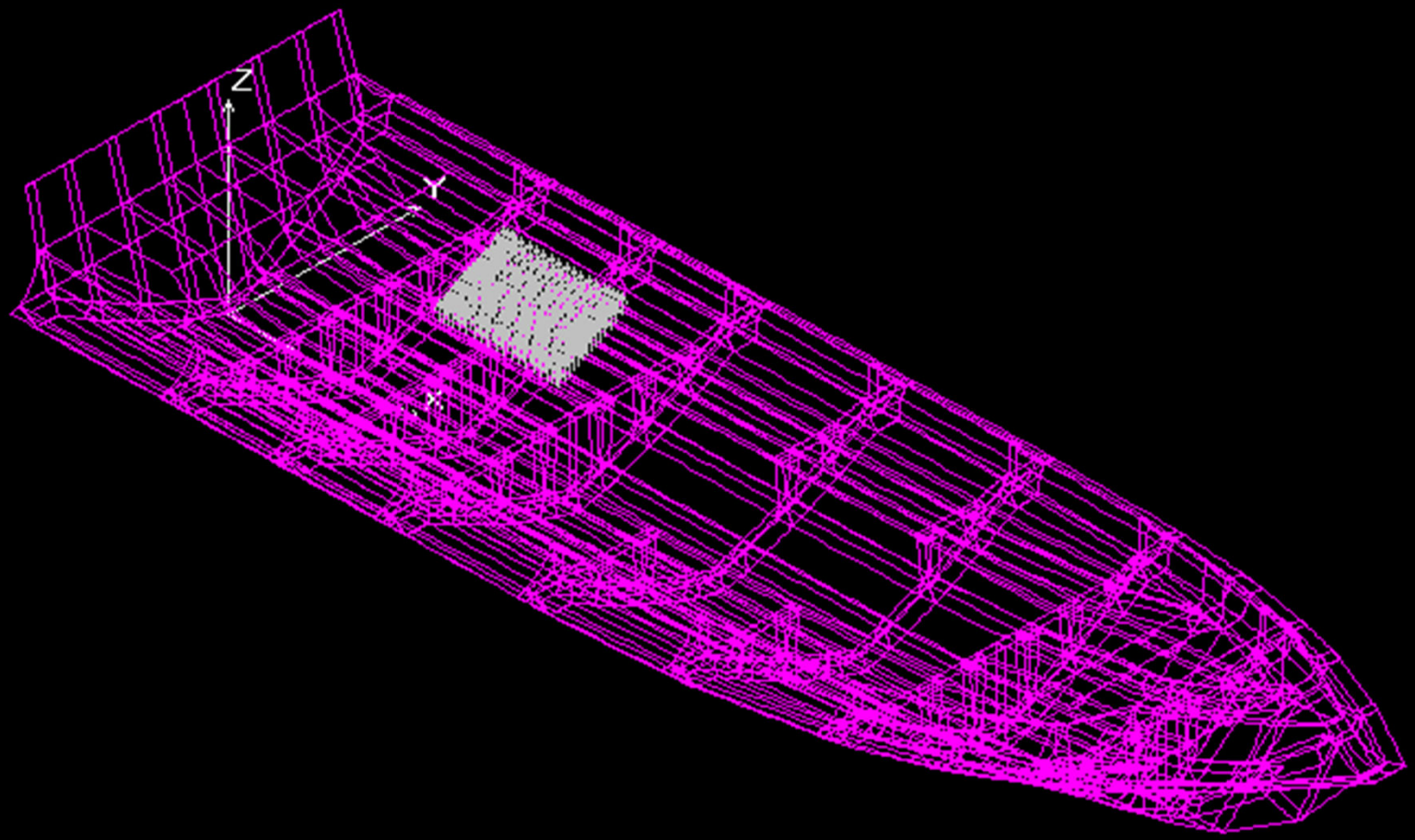
LC1- AMI-10 psi Pressure Load



LC1- AMI- Summary

- Deck range of deflection 0.30 in.
- Hull range of deflection 0.44 in.
- Local panel deflection 0.165 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 9,000 psi
- Maximum hull shell stress 5,000 psi

LC2- AMO-10 psi Pressure Load

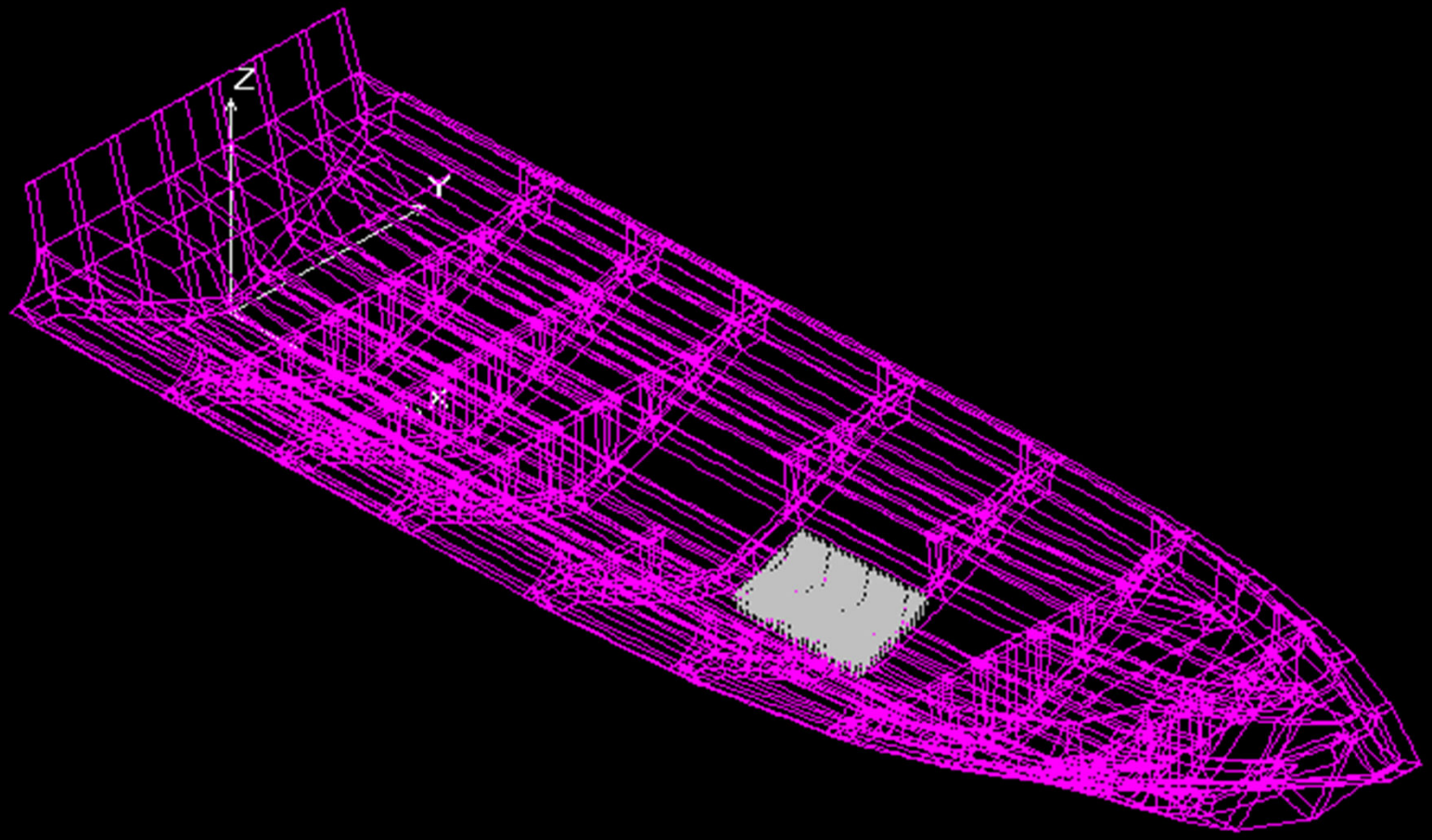


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LC2- AMO- Summary

- Deck range of deflection 0.56 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.17 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 10,500 psi
- Maximum hull shell stress 7,000 psi

LC3- FI-10 psi Pressure Load

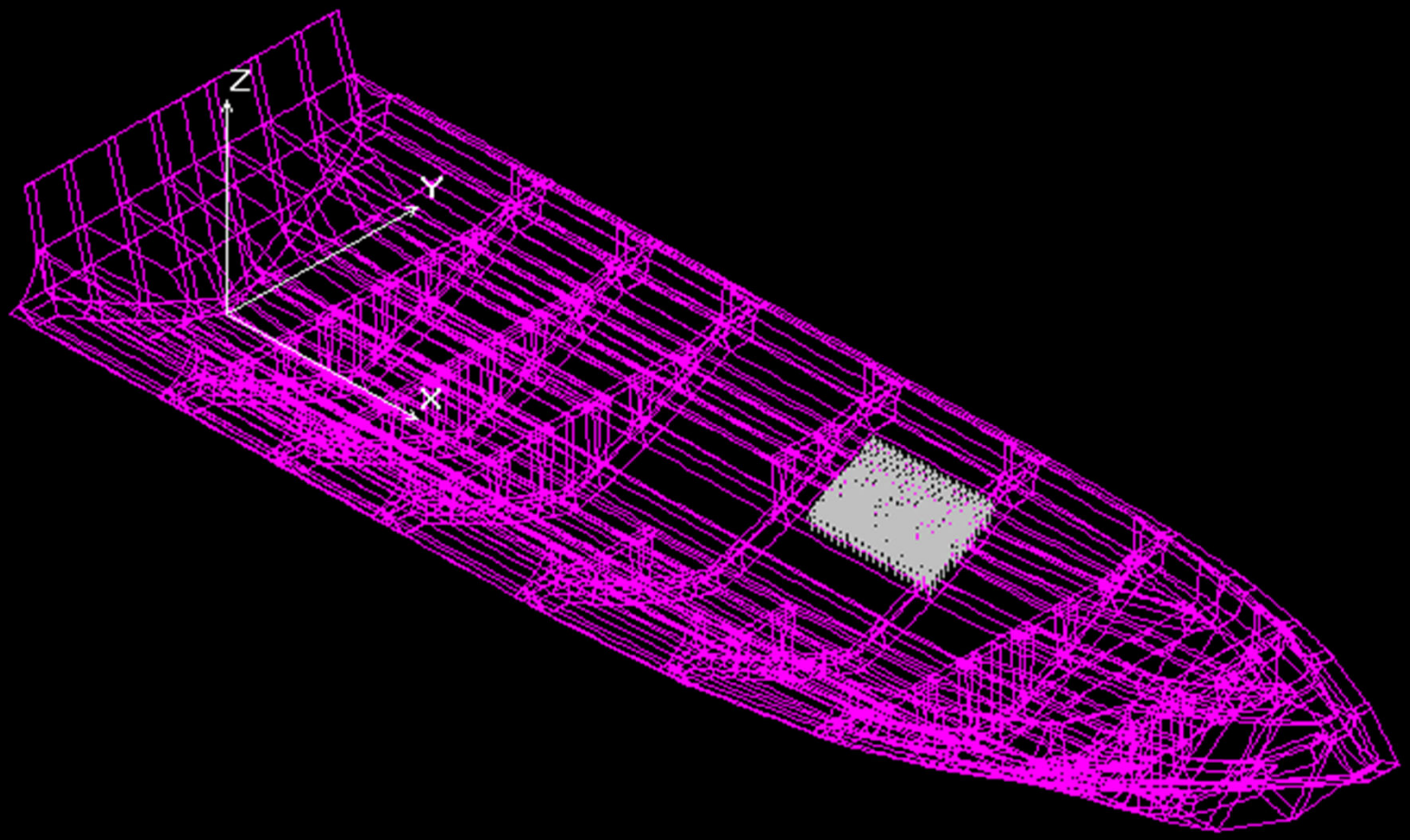


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LC3- FI- Summary

- Deck range of deflection 0.8 in.
- Hull range of deflection 0.8 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC4- FO-10 psi Pressure Load

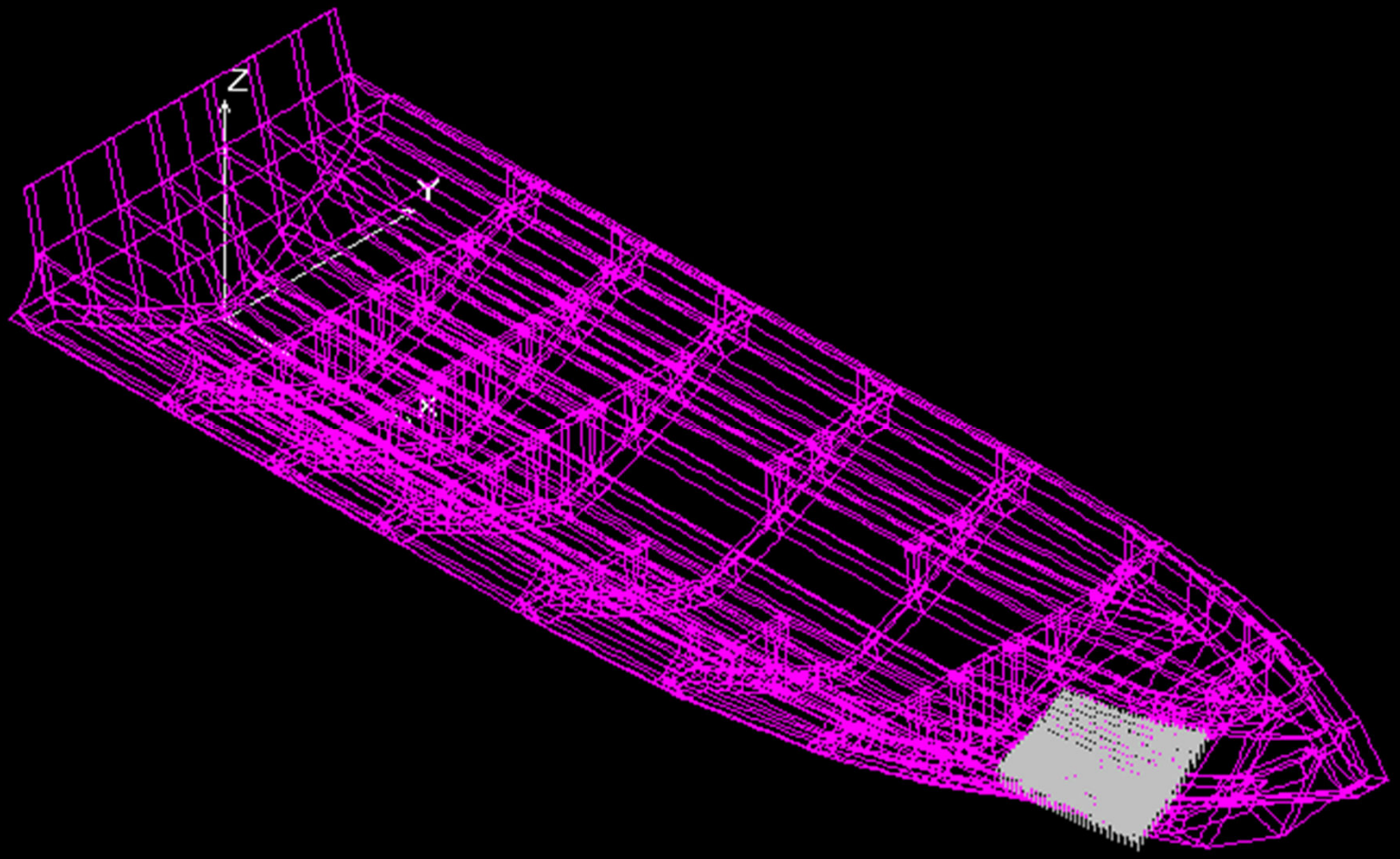


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LC4- FO- Summary

- Deck range of deflection 0.69 in.
- Hull range of deflection 1.0 in.
- Local panel deflection 0.36 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 19,000 psi
- Maximum hull shell stress 5,500 psi

LC5- STR-10 psi Pressure Load



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LC5- STR- Summary

- Deck range of deflection 0.52 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0035 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC(1-5)- SAS Summary

Range of maximum values in SAS cases

- Deck range of deflection 0.30-0.69 in.
- Hull range of deflection 0.44-1.0 in.
- Local panel deflection 0.16-0.36 in.
- Maximum strain 0.002-0.0035 in/in
- Maximum framing stress 9,000-19,000 psi
- Maximum hull shell stress 5,000-8,000 psi

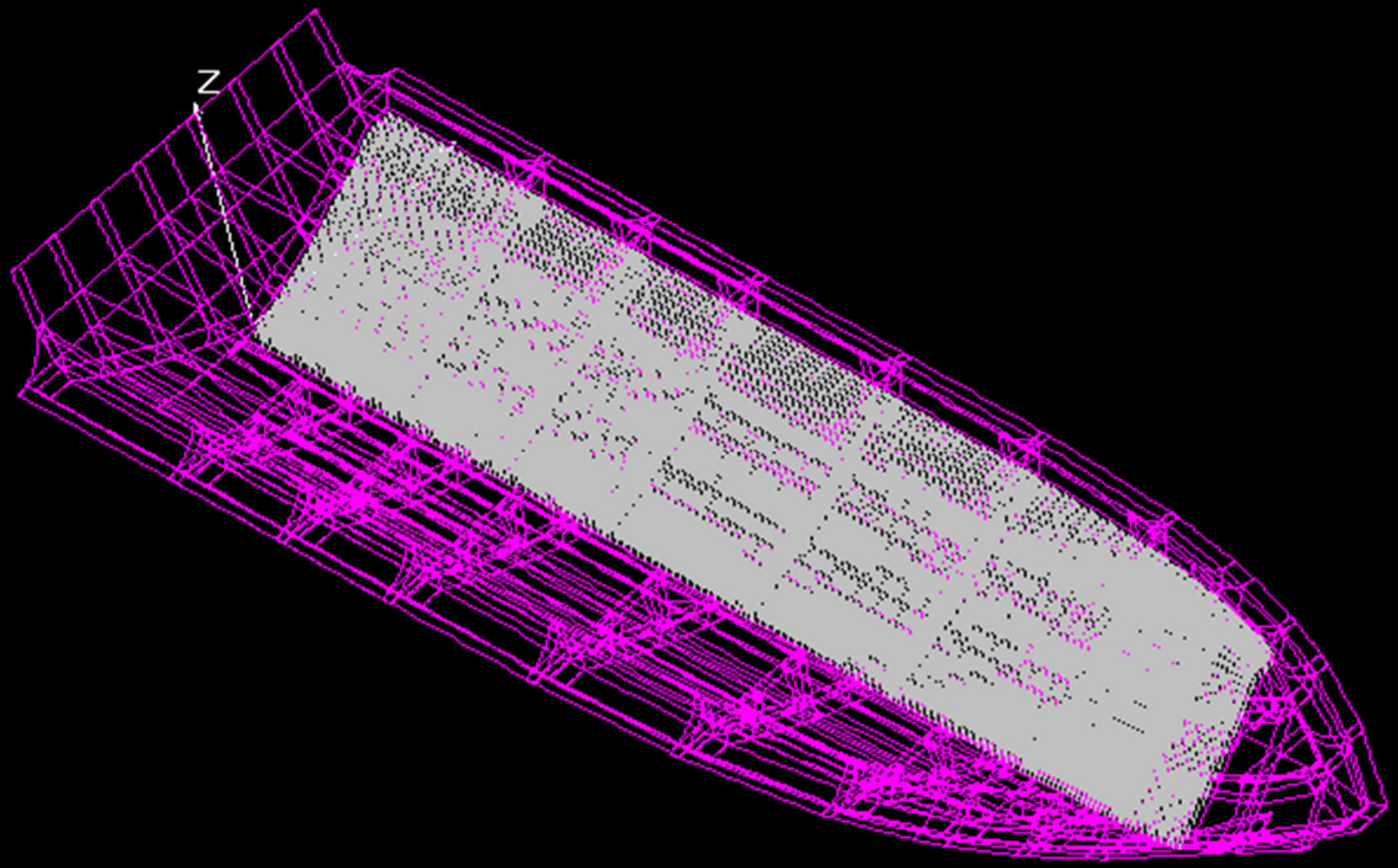
850A- FEA Analysis: Large Area Slam (LAS)



LC6-LAS- Loading

- Pressure load 4.68 psi
- Total load 44,000 lbs
- 11,000 lbs running weight at 4 g's

LC6-LAS- 4.68psi Pressure Load



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850A- LAS Summary

- Deck range of deflection 1.72 in.
- Hull range of deflection 2.19 in
- Local panel deflection 0.17 in.
- Maximum strain 0.025 in/in
- Maximum longitudinal stress 13,500 psi
- Maximum transverse stress 12,000 psi

850A- FEA Analysis: Calm Water Planning (C.W.P.)

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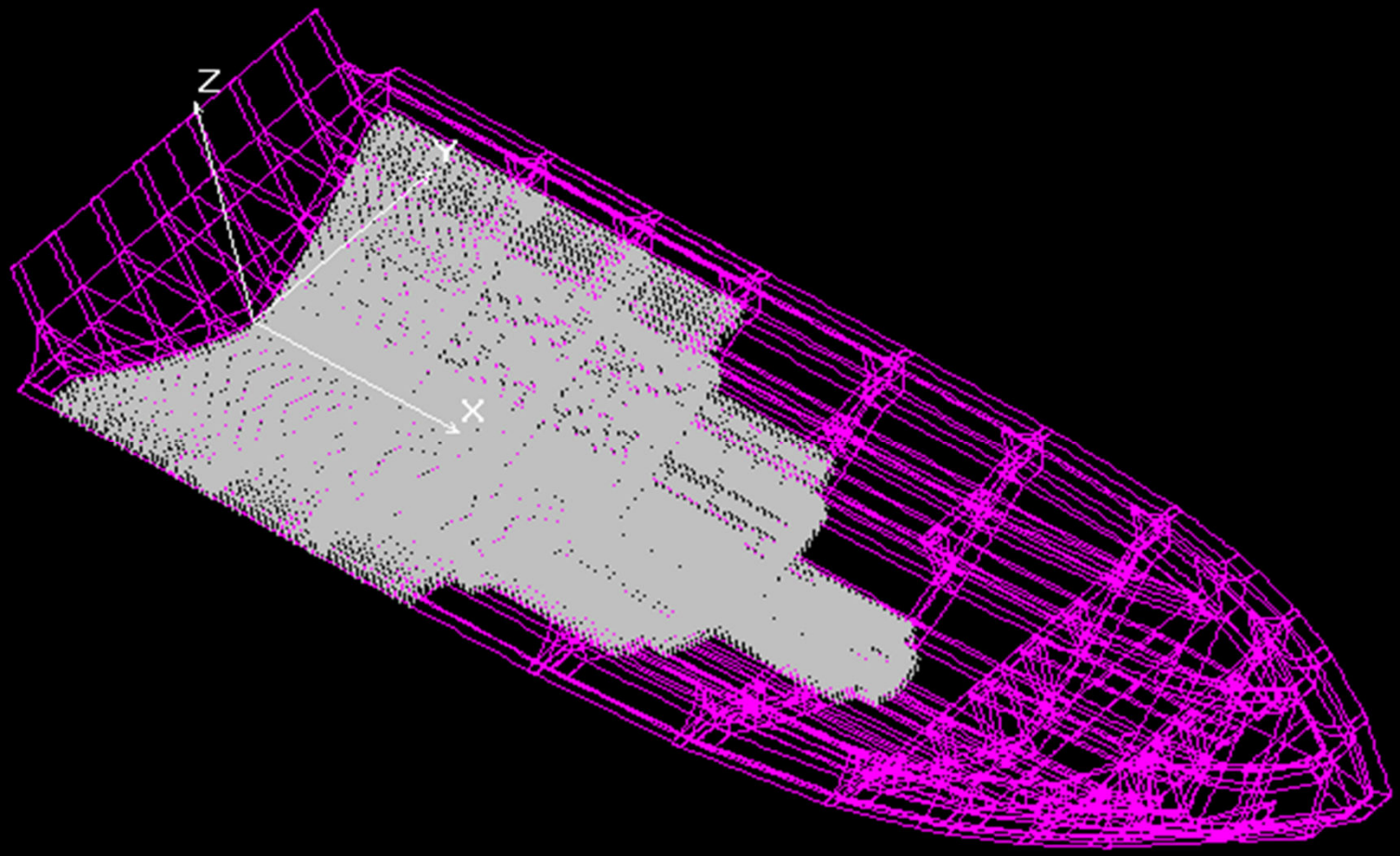
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LC7-CWP- Load

- Boat weight 11,000 lbs
- Bottom pressure 1.1 psi (11,000 lbs total)

LC7-CWP- 1.1psi Pressure Load



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850A- CWP Summary

- Range of deflection 0.52 in.
- Local panel deflection 0.025 in
- Maximum strain 0.0007 in/in
- Maximum longitudinal stress 2000 psi
- Maximum transverse stress 1800 psi

850A- FEA Analysis: Boat Lifting Points (B.L.P.)

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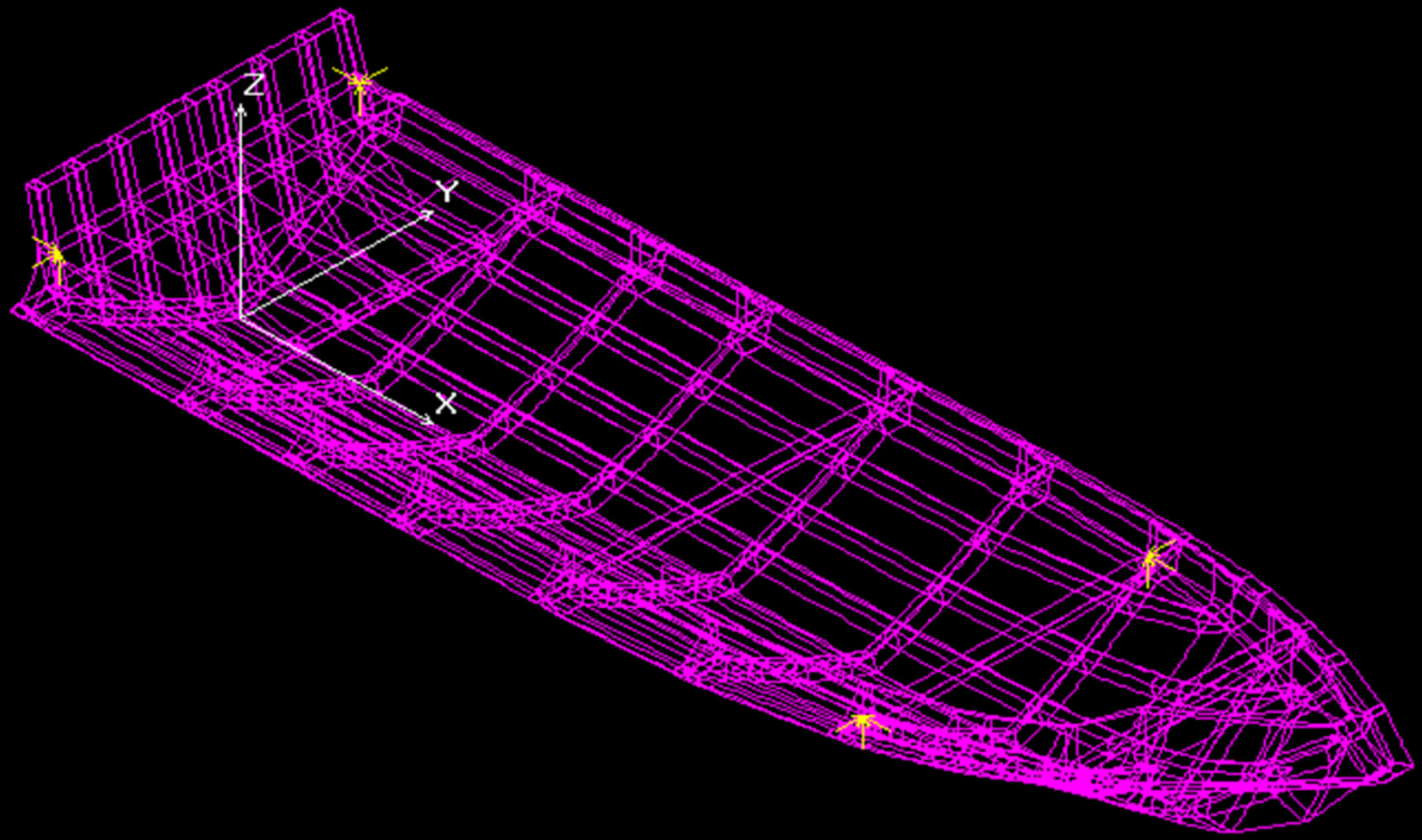
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
  - Redesigned to accommodate tube mounting.
  - Positioned for design LCG

LC8- BLP- Load Data

- Lift weight 7240, SF 6
- 4 point lift
- F_z all four lift points +10860 lbs
- F_x at aft two lift points +3430 lbs
- F_x at fwd two lift points -3430 lbs
- F_y at stbd two lift points +1300 lbs
- F_y at port two lift points -1300 lbs

LC8- BLP- Force Vector at Lift Points



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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints $F_r < 1$ lb
- Thus constraints do not affect results

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LC8- BLP- Lift Analysis Summary

- Model shows structure is adequate for this load case
- FOS: 6
- Range of deflection 1.7 in.
- Maximum strain at lift points 0.0067 in/in
- Maximum longitudinal stress 20,000 psi
- Maximum transverse stress 24,500 psi

850A- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

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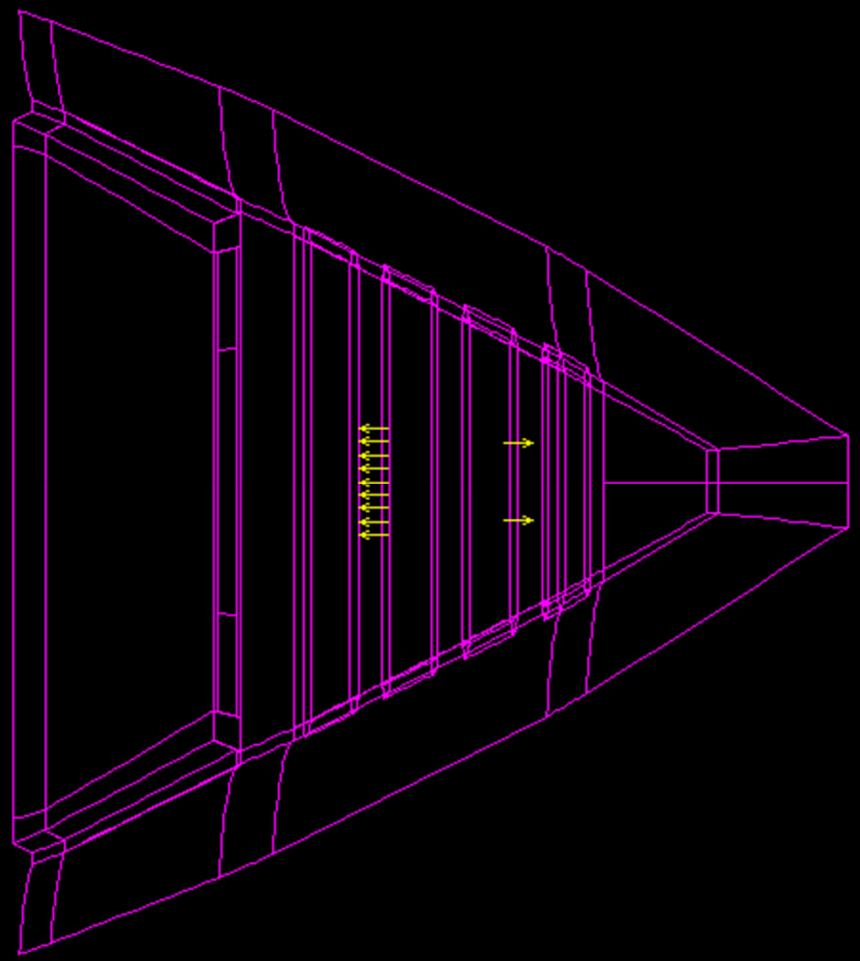
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Gun Mount Framing Notes

- Four transverse frames, TR3030X, are placed on five inch centers
- Skin laminate is four layers of 3610
- Frame laminate:
  - 24 oz (+/-45) on PRISMA Beam
  - 4 layers 1810 warp uni
  - 2408 (+/-45) cover fabric

LC9- GML- Long. Loading

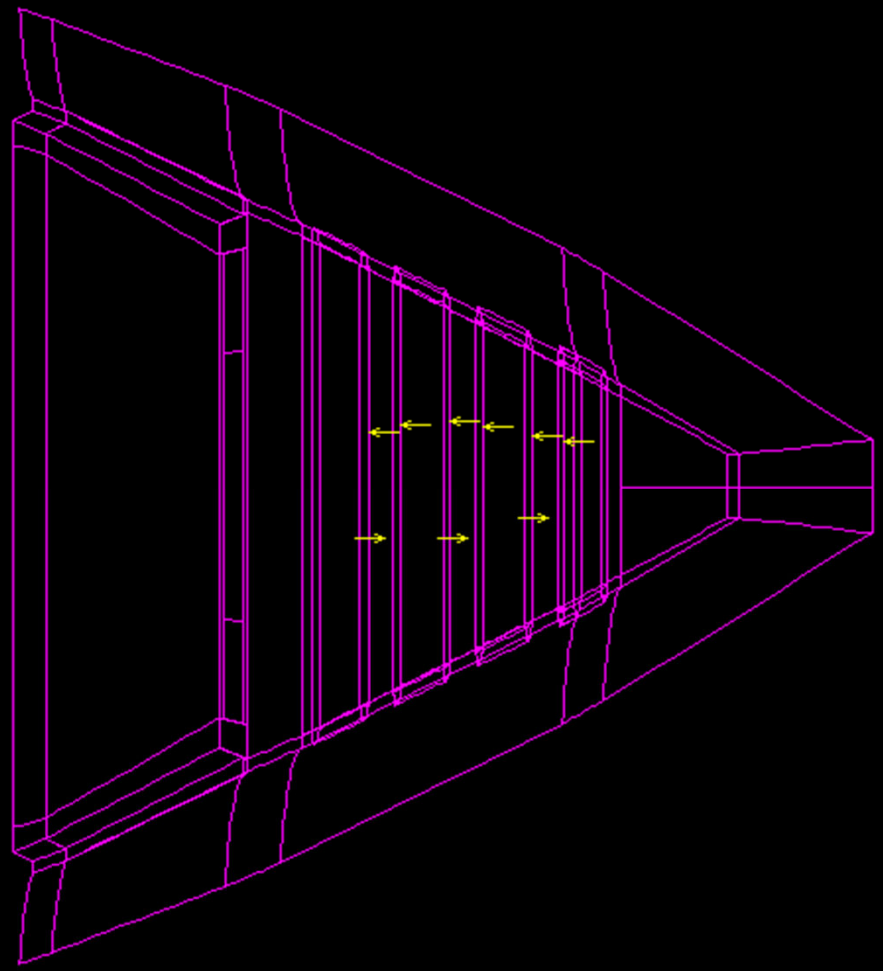


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850A- G.M.L- Summary

- Range of deflection 0.29 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 15,500 psi

LC10- GMT- Trans. Loading



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850A- G.M.T- Summary

- Range of deflection 0.25 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 5,000 psi

Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
  - Slight weight increase from Rev 0
- FOS for strength in excess of 10

Weight Projection 850A

A-Boat					
	Area (sqft)	Weight/Area oz/sqft	Weight (lb)	Rev 1 mod	Rev 2 (lb)
Hull	219.7	43.5	**597**	**18.5**	**616**
Deck	185.5	32.5	**377**	**26**	**403**
Hatch	32.1	32.5	**65**		**65**
Bulkheads	82.8	6	**31**		**31**
			1070		**1115**
	Length (ft)	**Weight/Length (oz/ft)**	**Weight (lb)**	**Rev 1 mod**	**Rev 2 (lb)**
Hull - TR4030	125	15.3	**119**		**119**
Deck - TR4010	130	6.0	**49**		**49**
Hatch TR4010	46	6.0	**17**		**17**
			185		**185**
		Rev 0	**1256**	**Rev 2**	**1300**
		Use Rev 0	**1381**	**Use Rev2**	**1430**

Weight Evaluation- Baseline

Boat Weights (lb)				
Segment	Baseline	850 A	850 B	850 B-OM
Fabrication Method	Open Mold	Open Mold	VARTM	Open Mold
Hull	1115	843	717	789
Deck	665	587	481	529
Console	540	350	350	350
Total	2320	1780	1548	1668
% Current	100%	77%	67%	72%
% Savings	--	23%	33%	28%

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 850A- Exceeds Metrics, On Target
  - 850B- Exceeds Metrics, On Target

850A- Extended Drawings and FEA Analysis Slides



850A- Complete Drawings Package

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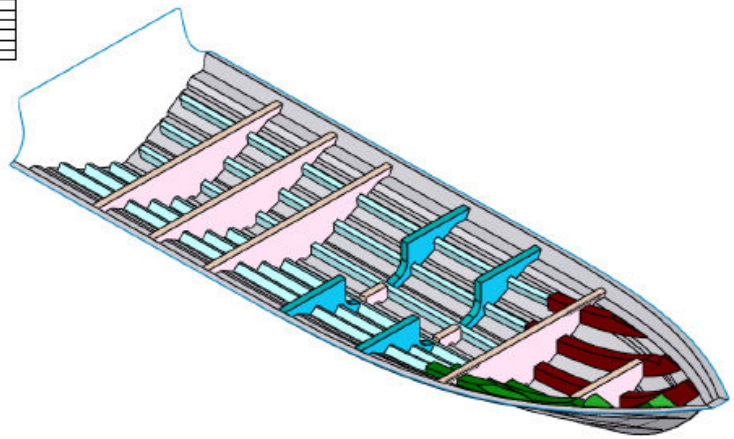
850A- Hull Drawings

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4	A/R	E LTM 3610 0/90 fabric	Vectorply	E-LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/- 45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/- 45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/- 45 fabric
9		not used			
10	A/R	E-LM T810 0 fabric - 3" wide	Vectorply	E-LM T810	0 fabric
11	A/R	3oz Chopped Strand Mat			
12	A/R	26lb Density Core	Acon baltek Corporation	PXC420	1-3/4" thick
13		not used			
14	90 LF	TR40S0A	Compsys	TR40S0A	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850MA-SPOS	
16	1	Starboard Mid Stringer	Compsys	BCG850MA-SPMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850MA-SPIS	
18	1	Port Outboard Stringer	Compsys	BCG850MA-PPOS	
19	1	Port Mid Stringer	Compsys	BCG850MA-PPMS	
20	1	Port Inboard Stringer	Compsys	BCG850MA-PPIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	1	Bulkhead A	Compsys	BCG850MA-BHA	
26	1	Bulkhead B	Compsys	BCG850MA-BHB	
27	2	Bulkhead C+D	Compsys	BCG850MA-BHC/D	
28	3	Bulkhead E-F-G	Compsys	BCG850MA-BHE,F,G	
29	2	Bulkhead Wing C (P&S)	Compsys	BCG850MA-PSWC	
30	2	Bulkhead Wing D (P&S)	Compsys	BCG850MA-PSWD	
31	95 LF	FSu2010	Compsys	FSu2010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

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7705 TECHNOLOGY DRIVE
W. MELBOURNE, FL 32904-1576 (USA)

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DRAWING TITLE: 850A HULL

DATE: 4/7/2011
DRAWN: TEB/BALTAZAR
CHECKED: XXXXXXXXXXX
APRVD: XXXXXXXXXXX

SCALE: NTS | JOB No. | DWG No. 850-850A-1 | SHEET 1 OF 5 | REV

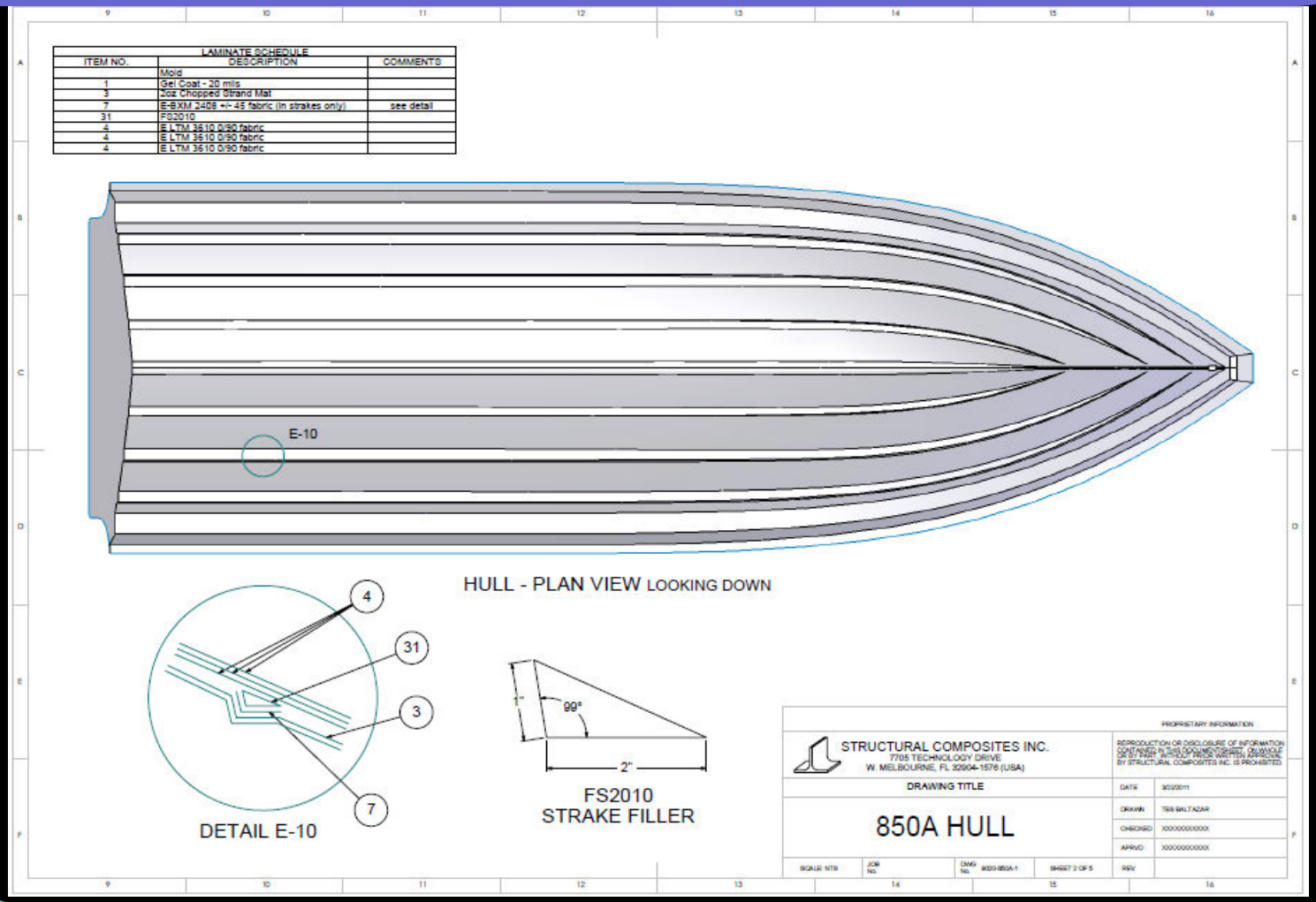
STRUCTURAL COMPOSITES ® LOCKHEED MARTIN ATI ZODIAC®

850A- Hull Drawings- BOM

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/- 45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/- 45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/- 45 fabric
9		not used			
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
11	A/R	3oz Chopped Strand Mat			
12	A/R	26lb Density Core	Alcan Baltek Corporation	PXC420	1-3/4" thick
13		not used			
14	90 LF	TR4030X	Compsys	TR4030X	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850IMA-SFOS	
16	1	Starboard Mid Stringer	Compsys	BCG850IMA-SFMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850IMA-SFIS	
18	1	Port Outboard Stringer	Compsys	BCG850IMA-PFOS	
19	1	Port Mid Stringer	Compsys	BCG850IMA-PFMS	
20	1	Port Inboard Stringer	Compsys	BCG850IMA-PFIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	1	Bulkhead A	Compsys	BCG850IMA-BH7	
26	1	Bulkhead B	Compsys	BCG850IMA-BH6	
27	2	Bulkhead C-D	Compsys	BCG850IMA-BH4,5	
28	3	Bulkhead E-F-G	Compsys	BCG850IMA-BH1,2,3	
29	2	Bulkhead Wing C (P&S)	Compsys	BCG850IMA-P/SW2	
30	2	Bulkhead Wing D (P&S)	Compsys	BCG850IMA-P/SW1	
31	95 LF	FS2010	Compsys	FS2010	

850A- Hull Drawings



LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
3	2oz Chopped Strand Mat	
7	E-BXM 2408 +/- 45 fabric (In strakes only)	see detail
31	FS2010	
4	E LTM 3610 0/90 fabric	
4	E LTM 3610 0/90 fabric	
4	E LTM 3610 0/90 fabric	

HULL - PLAN VIEW LOOKING DOWN

DETAIL E-10

FS2010
STRAKE FILLER

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DRAWING TITLE

850A HULL

DATE	3/2/2011
DRAWN	TBS BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
SCALE: NTS	
JOB No.	
DWG No.	9000-850A-1
SHEET 2 OF 5	
REV	

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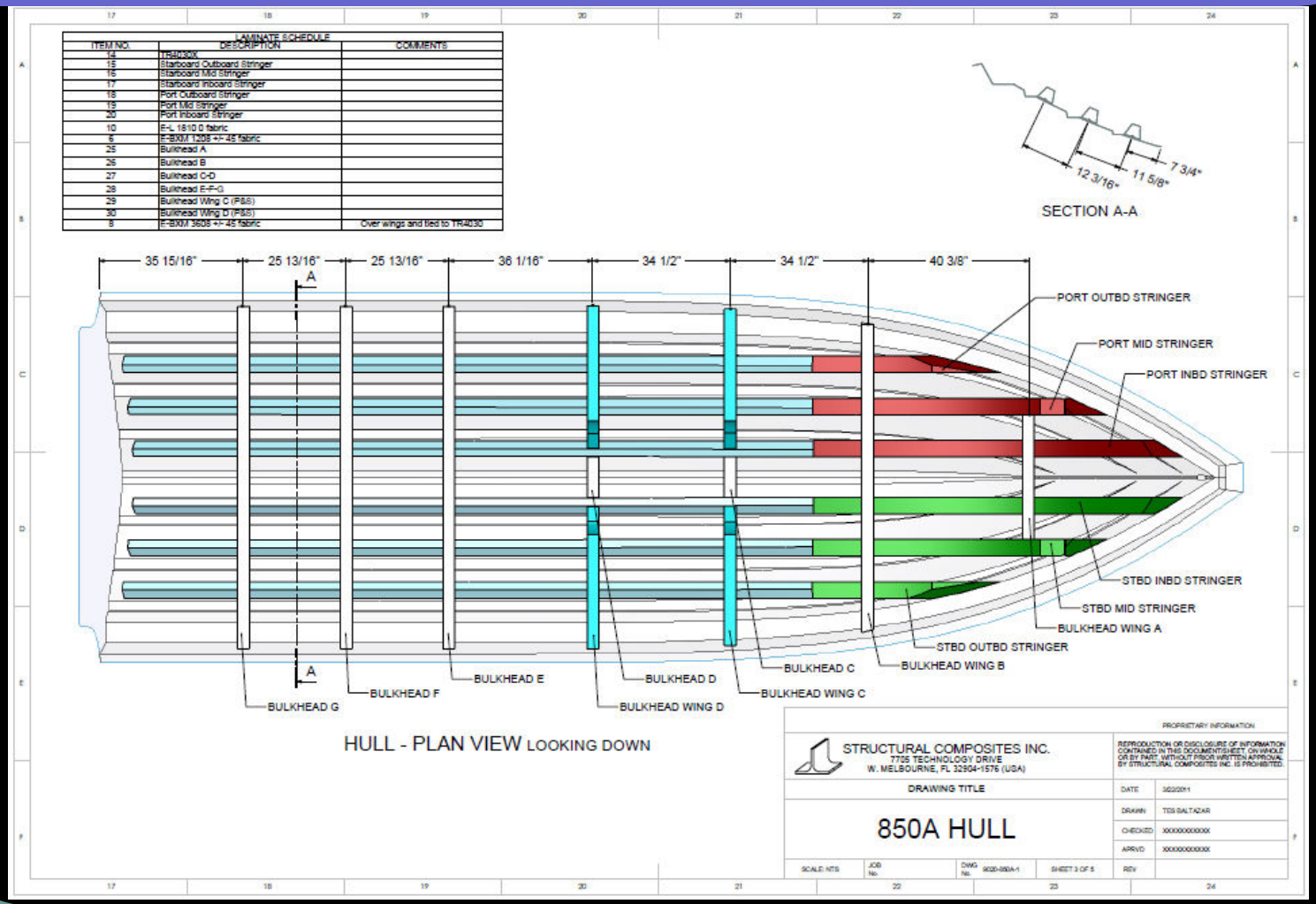
LOCKHEED MARTIN

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BRUNSWICK COMMERCIAL & GOVERNMENT PRODUCTS

850A- Hull Drawings



LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
14	TR4030X	
15	Starboard Outboard Stringer	
16	Starboard Mid Stringer	
17	Starboard Inboard Stringer	
18	Port Outboard Stringer	
19	Port Mid Stringer	
20	Port Inboard Stringer	
10	E-L 1810 0 fabric	
6	E-BXM 1208 +/- 45 fabric	
25	Bulkhead A	
26	Bulkhead B	
27	Bulkhead C-D	
28	Bulkhead E-F-G	
29	Bulkhead Wing C (P&S)	
30	Bulkhead Wing D (P&S)	
8	E-BXM 3608 +/- 45 fabric	Over wings and tied to TR4030

SECTION A-A

HULL - PLAN VIEW LOOKING DOWN

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DRAWING TITLE

850A HULL

DATE	3/22/2011
DRAWN	TDS BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 8520-850A-1 | SHEET 3 OF 5

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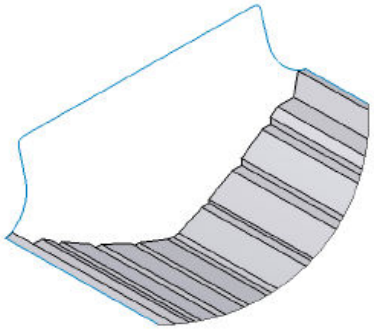
LOCKHEED MARTIN

ATI

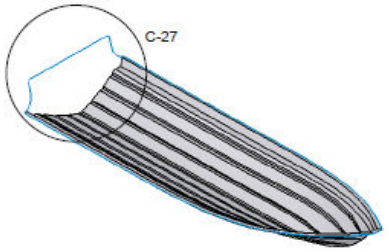
ZODIAC®

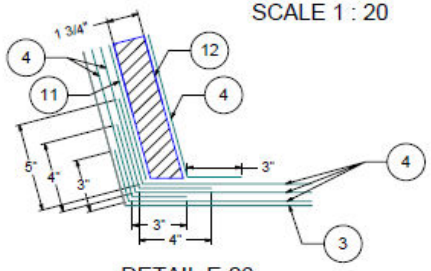
850A- Hull Drawings

LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
3	2oz Chopped Strand Mat	
4	E LTM 3610 D/90 fabric	
4	E LTM 3610 D/90 fabric	
11	3oz Chopped Strand Mat	
12	26lb Density Core	
4	E LTM 3610 D/90 fabric	



DETAIL C-27
SCALE 1 : 20





DETAIL E-26

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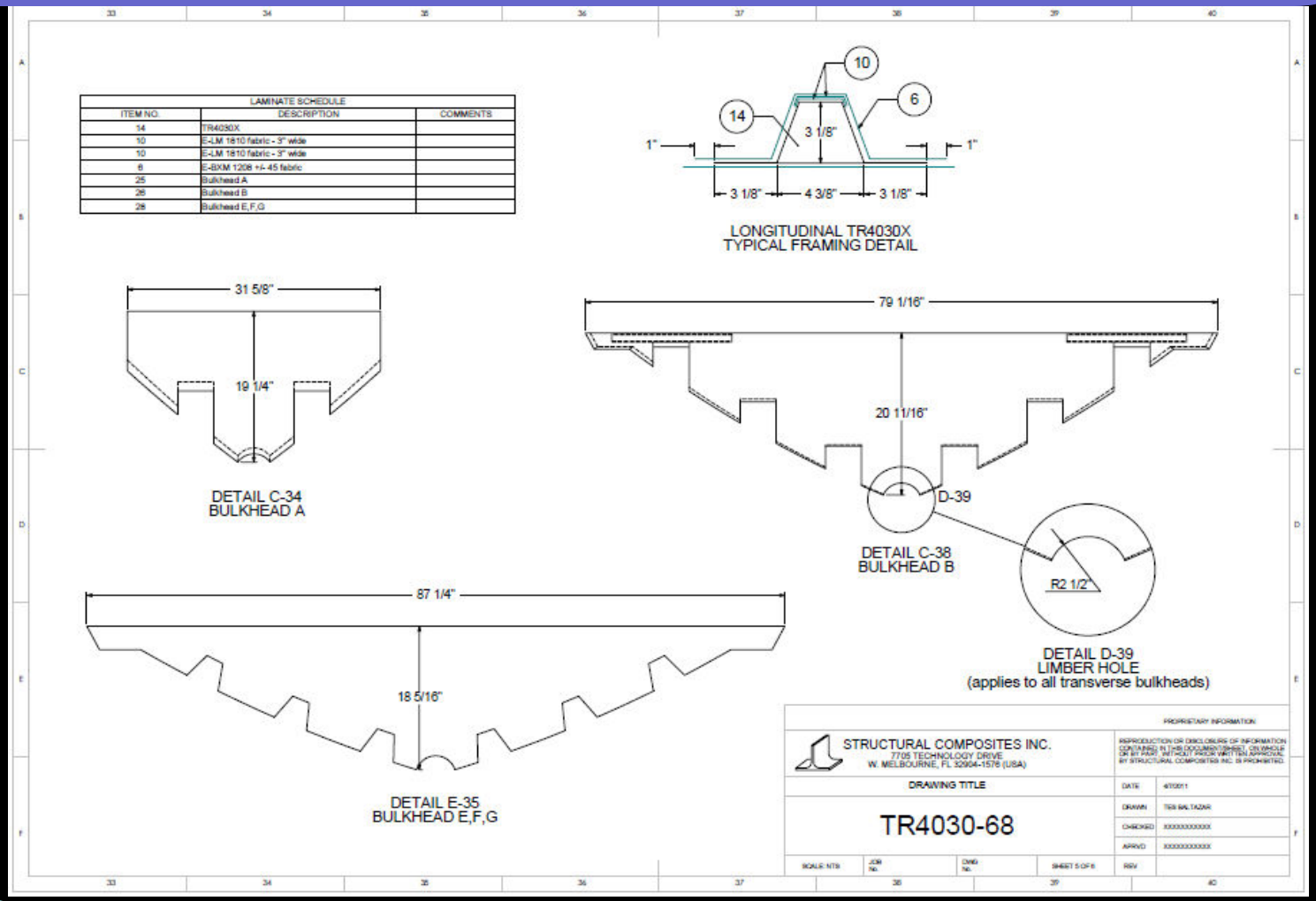
850A HULL

DATE	3/25/2011
DRAWN	TEG GALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9020-850A-1 | SHEET 4 OF 5

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850A- Hull Drawings



LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
14	TR4030X	
10	E-LM 1810 fabric - 3" wide	
10	E-LM 1810 fabric - 3" wide	
6	E-BXM 1208 +/- 45 fabric	
25	Bulkhead A	
26	Bulkhead B	
28	Bulkhead E,F,G	

LONGITUDINAL TR4030X
TYPICAL FRAMING DETAIL

DETAIL C-34
BULKHEAD A

DETAIL C-38
BULKHEAD B

DETAIL D-39
LIMBER HOLE
(applies to all transverse bulkheads)

DETAIL E-35
BULKHEAD E,F,G

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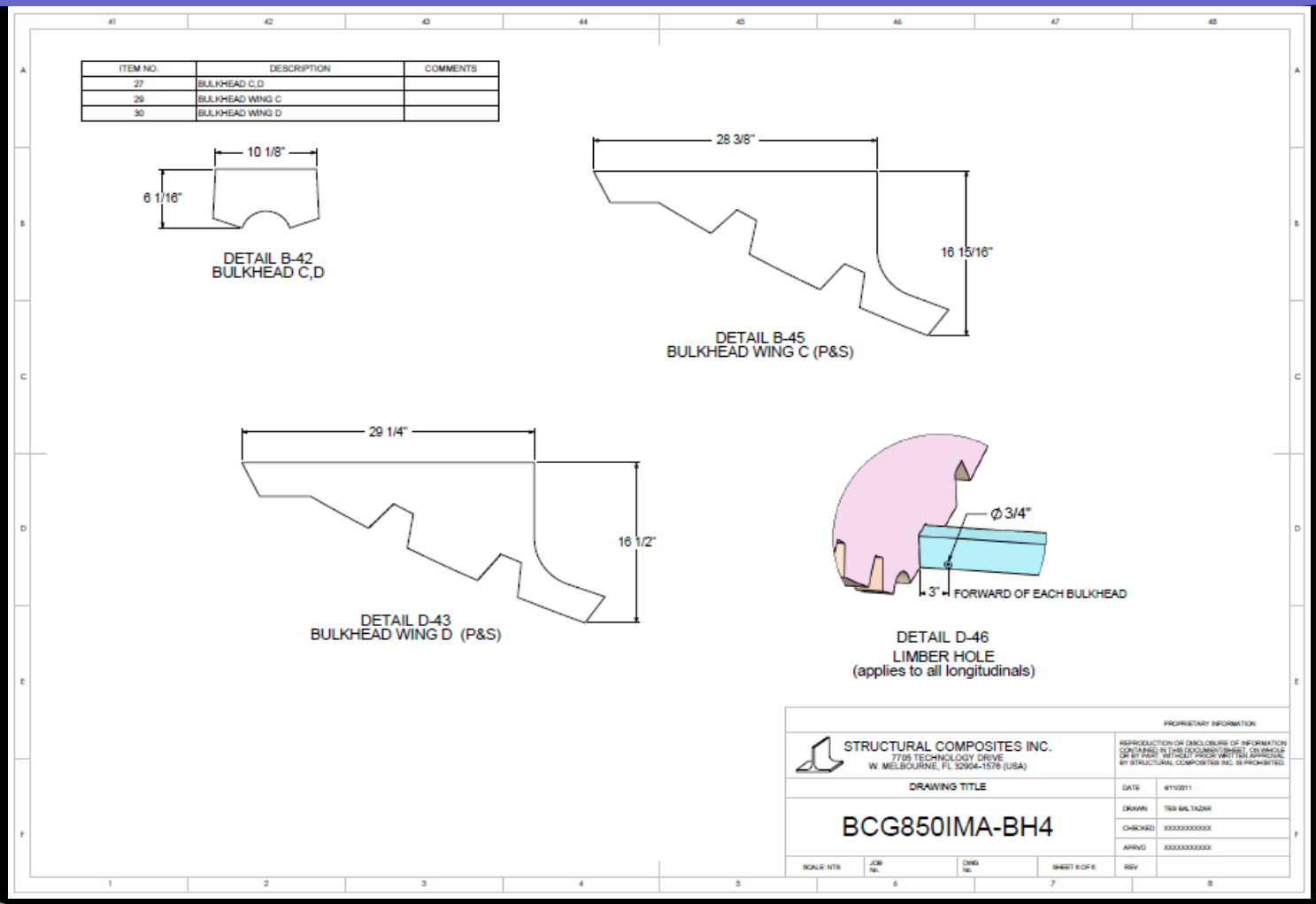
TR4030-68

DATE	4/7/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. | SHEET 5 OF 6

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850A- Hull Drawings



ITEM NO.	DESCRIPTION	COMMENTS
27	BULKHEAD C,D	
29	BULKHEAD WING C	
30	BULKHEAD WING D	

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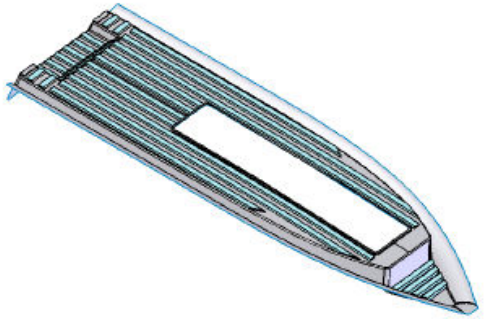
850A- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC KO22-EB8-00 Resin	Alpha Owens Corning	KO22-EB8-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E L7M 3610 0/90 fabric	Vectorply	E L7M 3610	0/90 fabric
5		not used			
6		not used			
7	A/R	E-BXM 2406 +/- 45 fabric	Vectorply	E-BXM 2406	+/-45 fabric
8	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
9	130 LF	TR4010	Compsys	TR4010	
10	10 LF	TR3030X	Compsys	TR3030X	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
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3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

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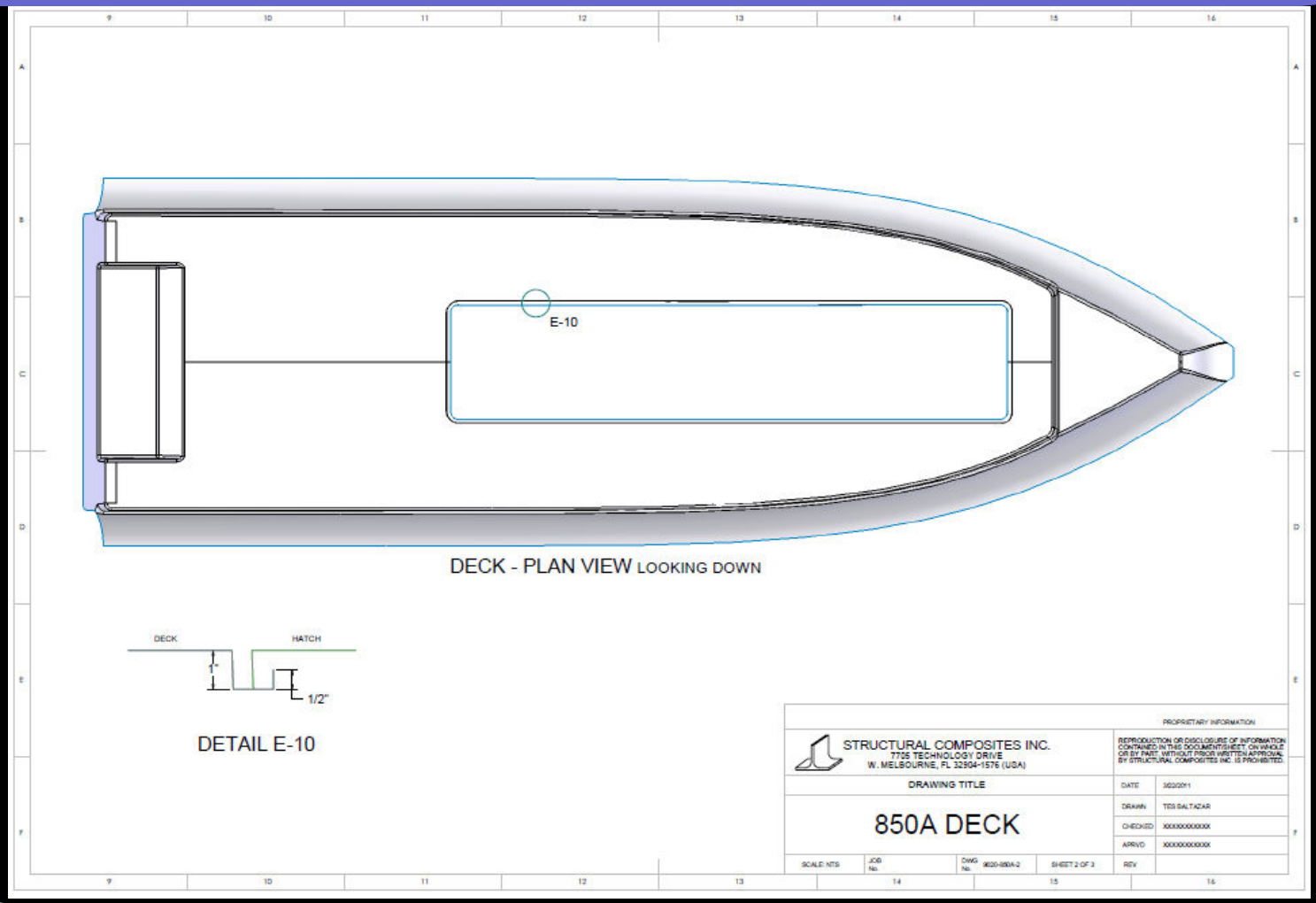
850A DECK

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9000-850A-2 | SHEET 1 OF 3

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850A- Deck Drawings



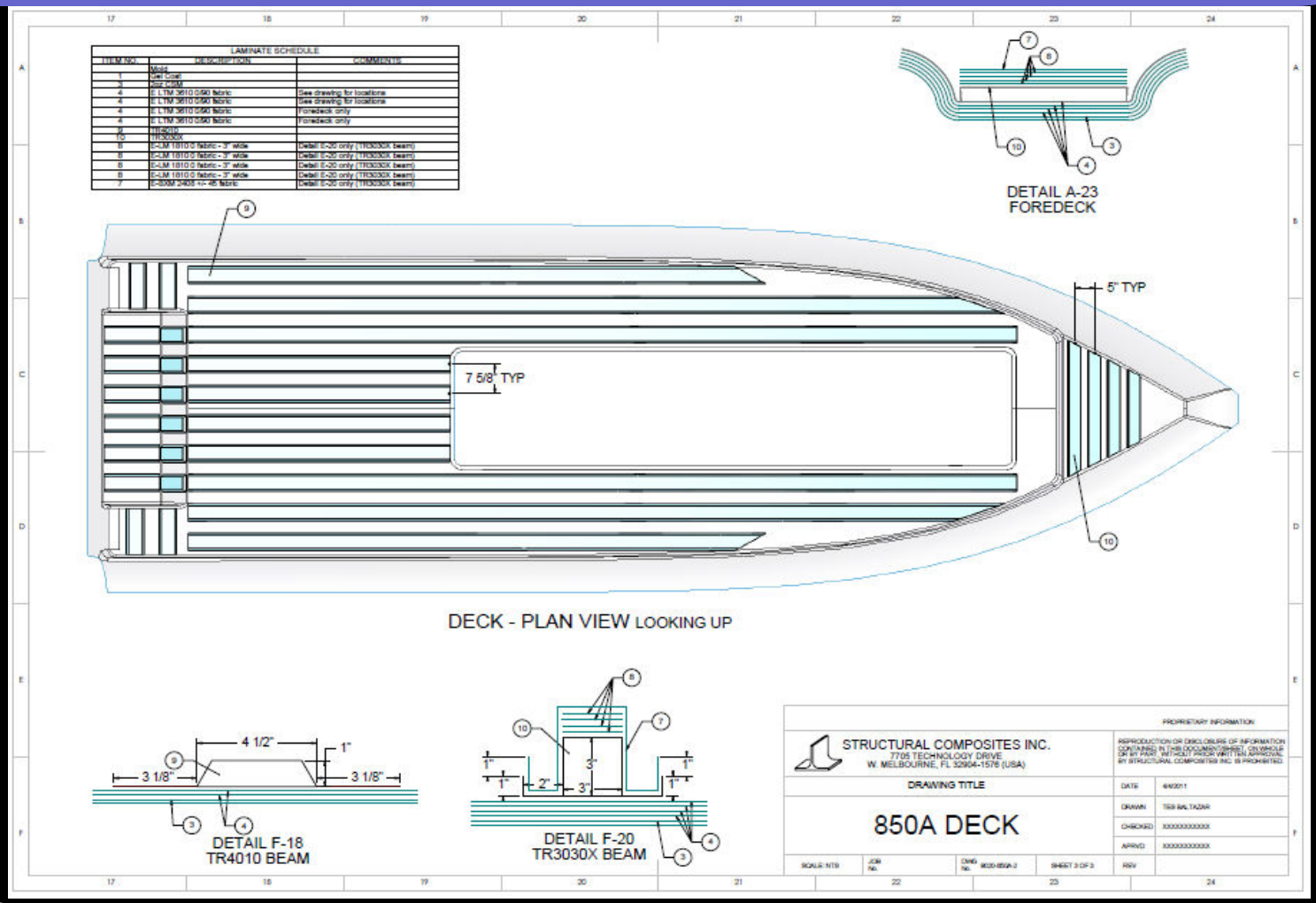
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850A- Deck Drawings



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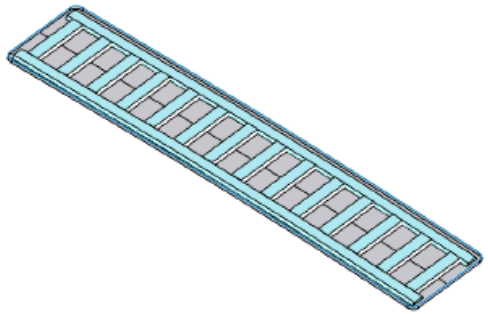
850A- Hatch Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC K022-EBB-00 Resin	Alpha Owens Corning	K022-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
8	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
14	50 LF	TR4010	Compsys	TR4010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
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2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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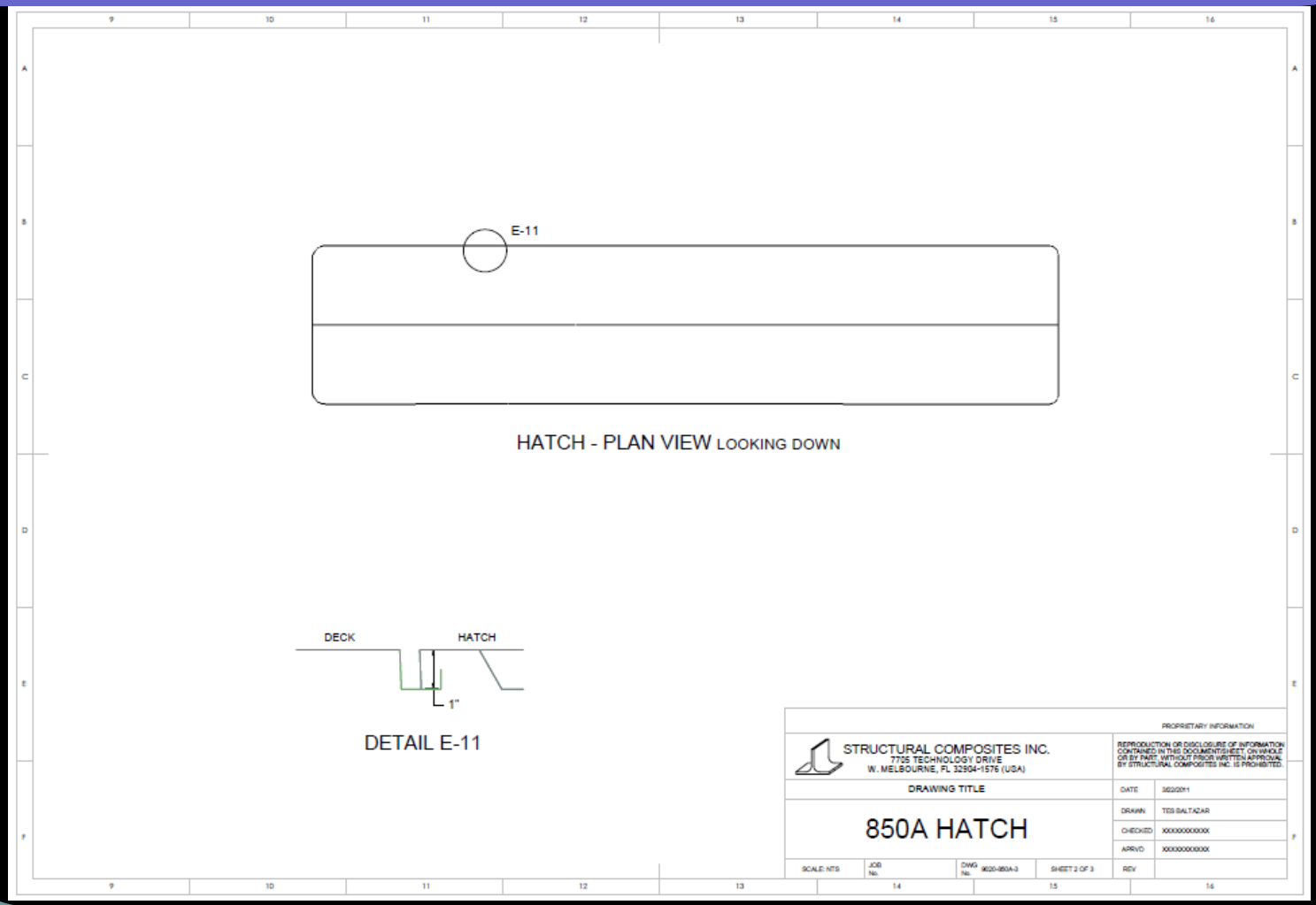
850A HATCH

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 8020-850A-0 | SHEET 1 OF 3

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850A- Hatch Drawings



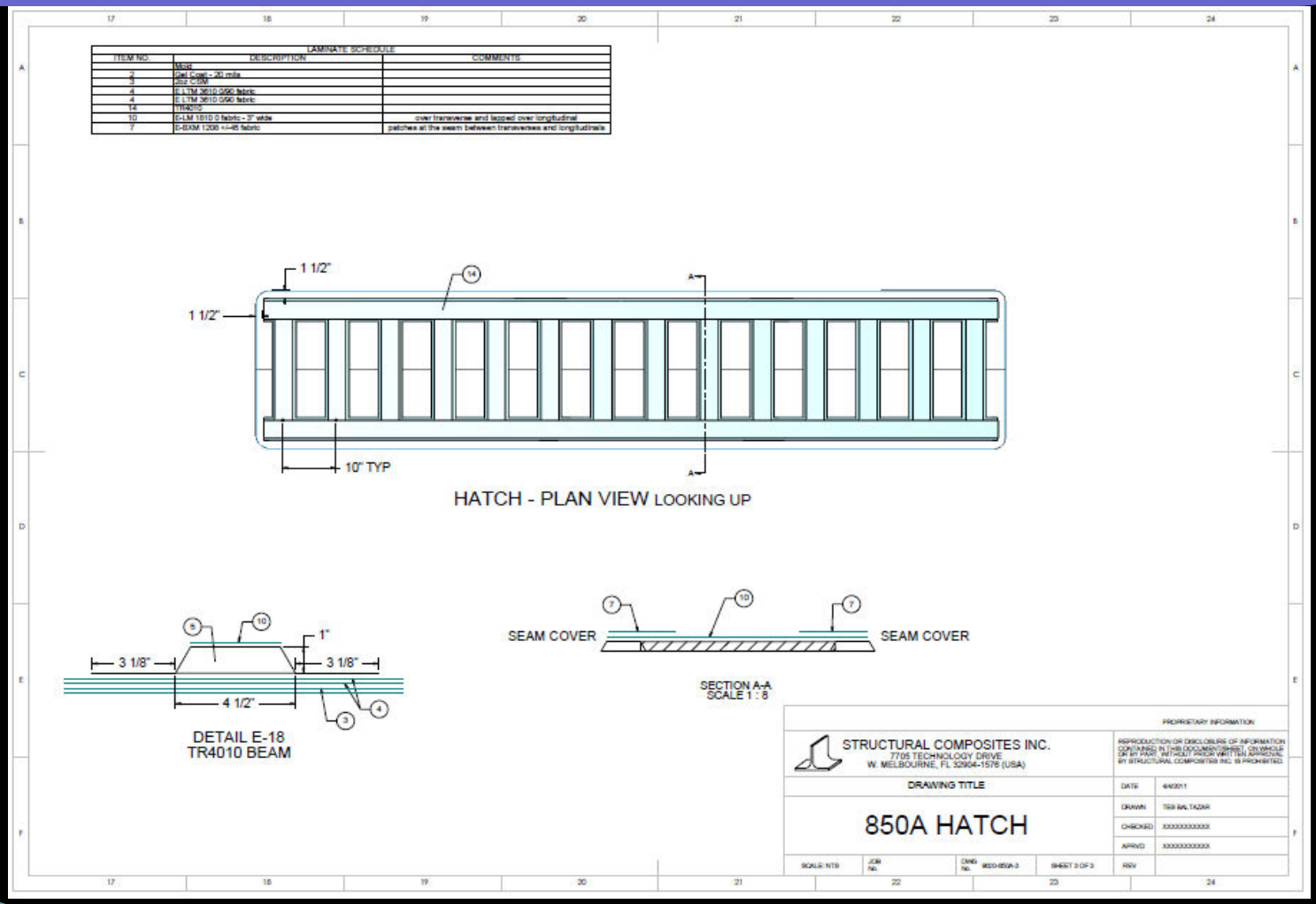
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850A- Hatch Drawings



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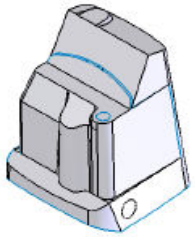
850A- Hardware- Console

BOM

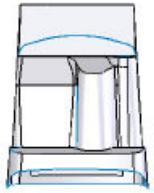
ITEM NO.	QTY	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS

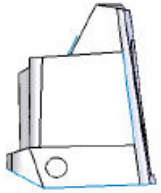
REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED









GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

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DRAWING TITLE

850A CONSOLE

DATE	3/25/2011
DRAWN	TED BALTAZAR
CHECKED	XXXXXXXXXXX
APPVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB NO. | DWG NO. 850-850A-1 | SHEET 1 OF 1

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850A – Laminate Schedule

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 3 x 3610
- Stringers – TR4030X /1810 / 1208 / 3608
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 3610 / 2408 / 1810 / TR4010 / TR3030X
- Deck Framing – Gel Coat / 2oz CSM / 4 x 3610 / TR4010 / TR3030X / 4 x 1810 / 2408
- Transom – Gel Coat / 2oz CSM / 2 x 3610 / 3oz CSM / 26lb Density Core / 3610

850A- Complete FEA Analysis











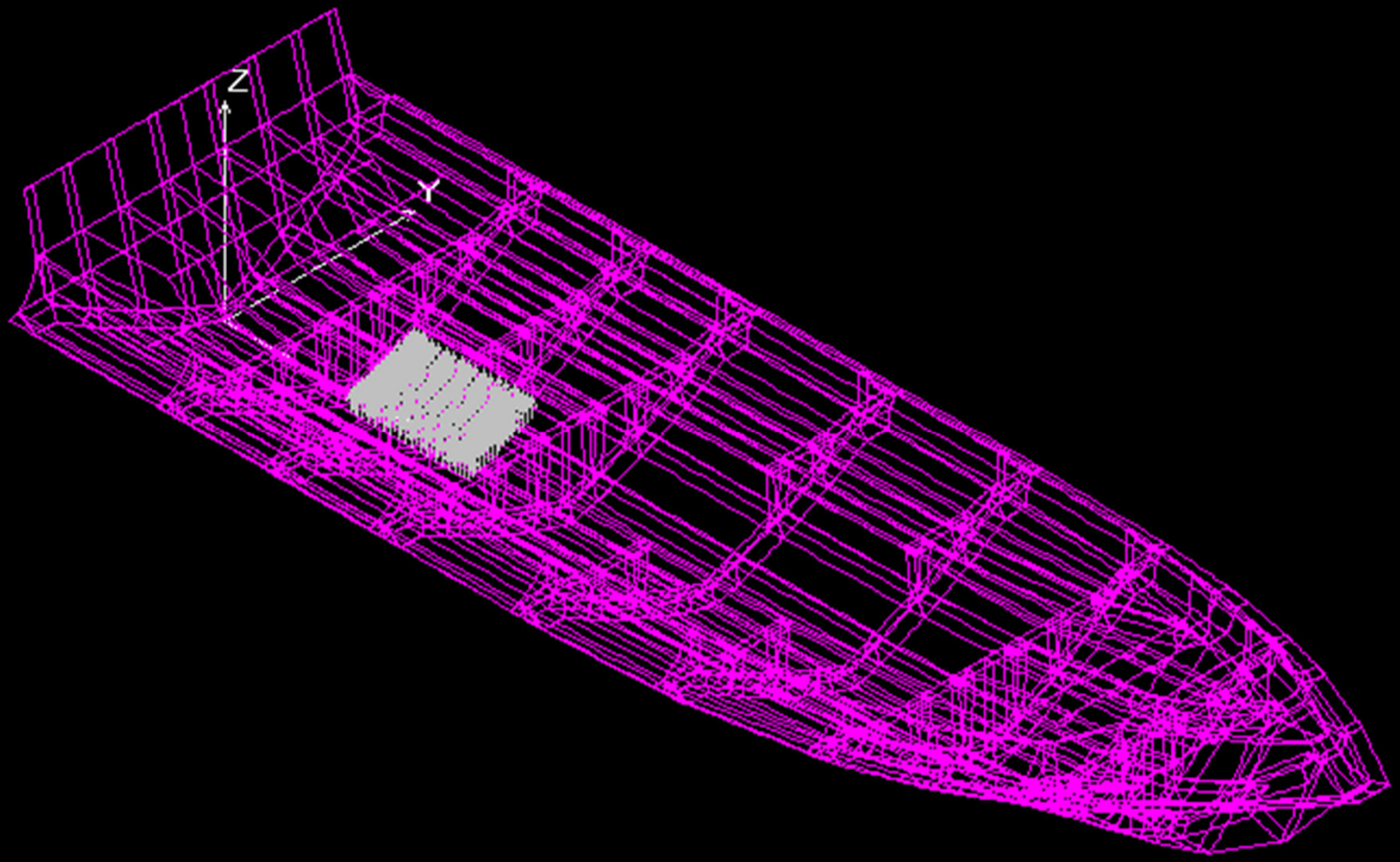
850A- FEA Analysis: Small Area Slamming (SAS)



Small Area Pressure Load

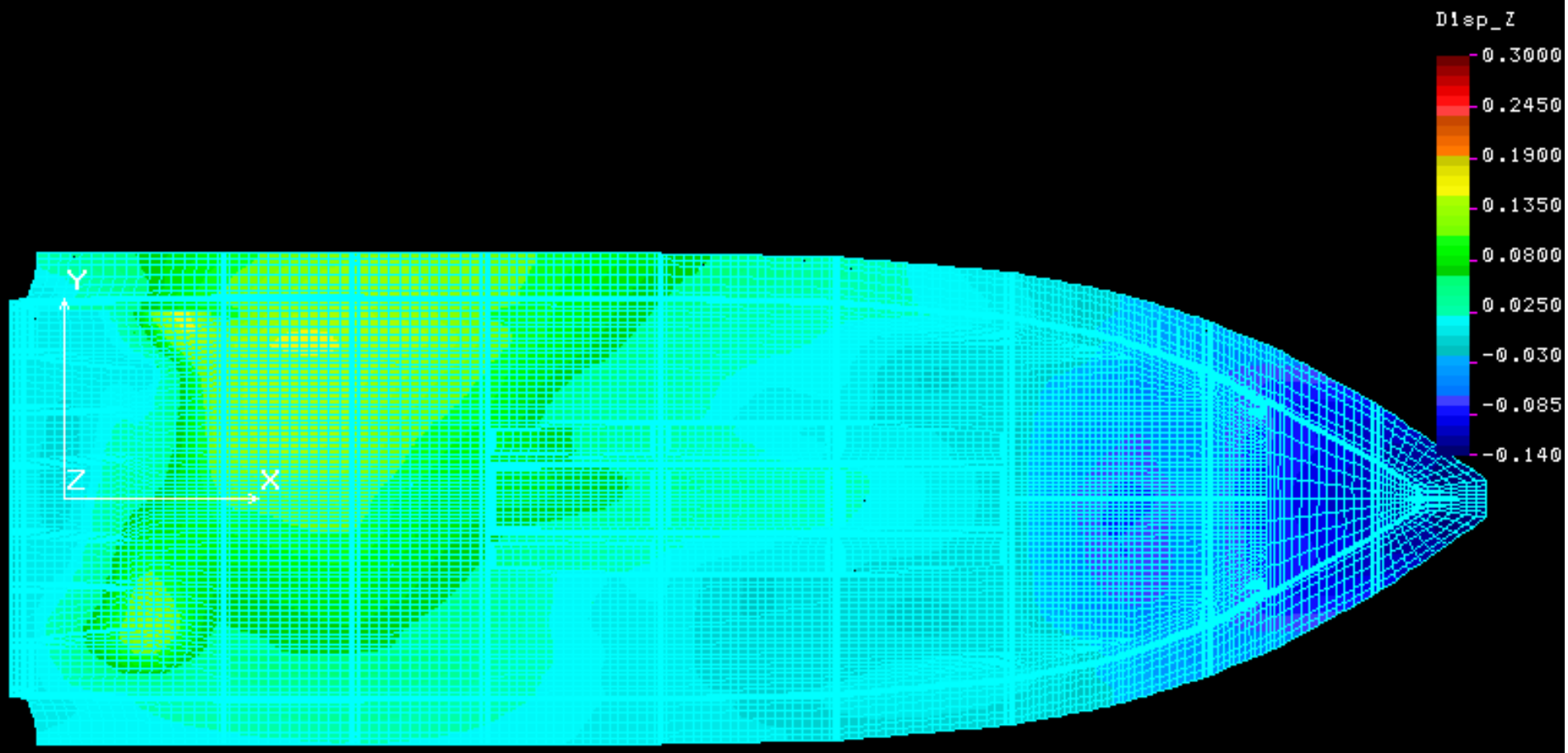
- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

LC1- AMI-10 psi Pressure Load



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LC1- AMI- Z Displacement- Deck



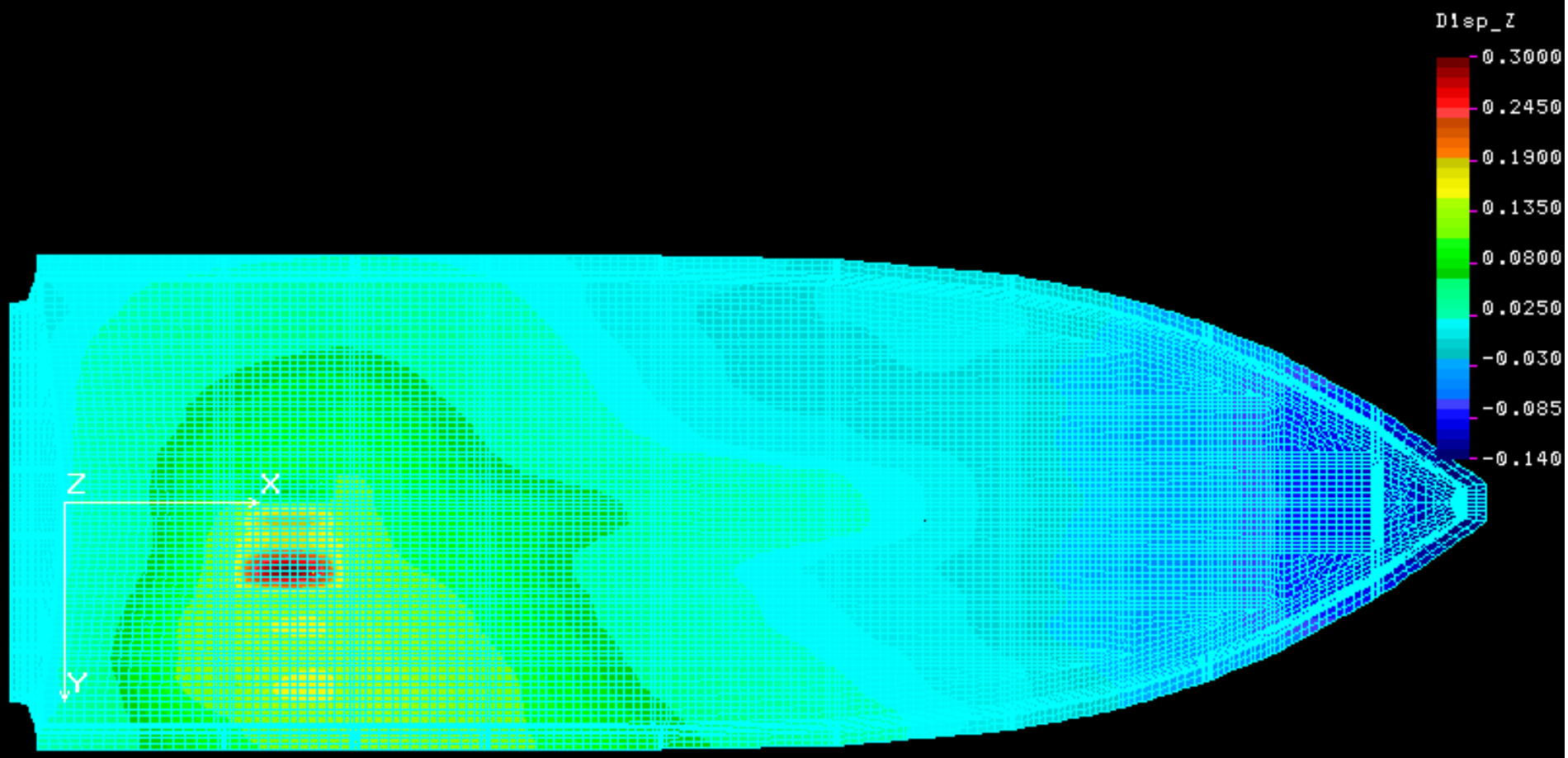
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LC1- AMI- Z Displacement- Hull



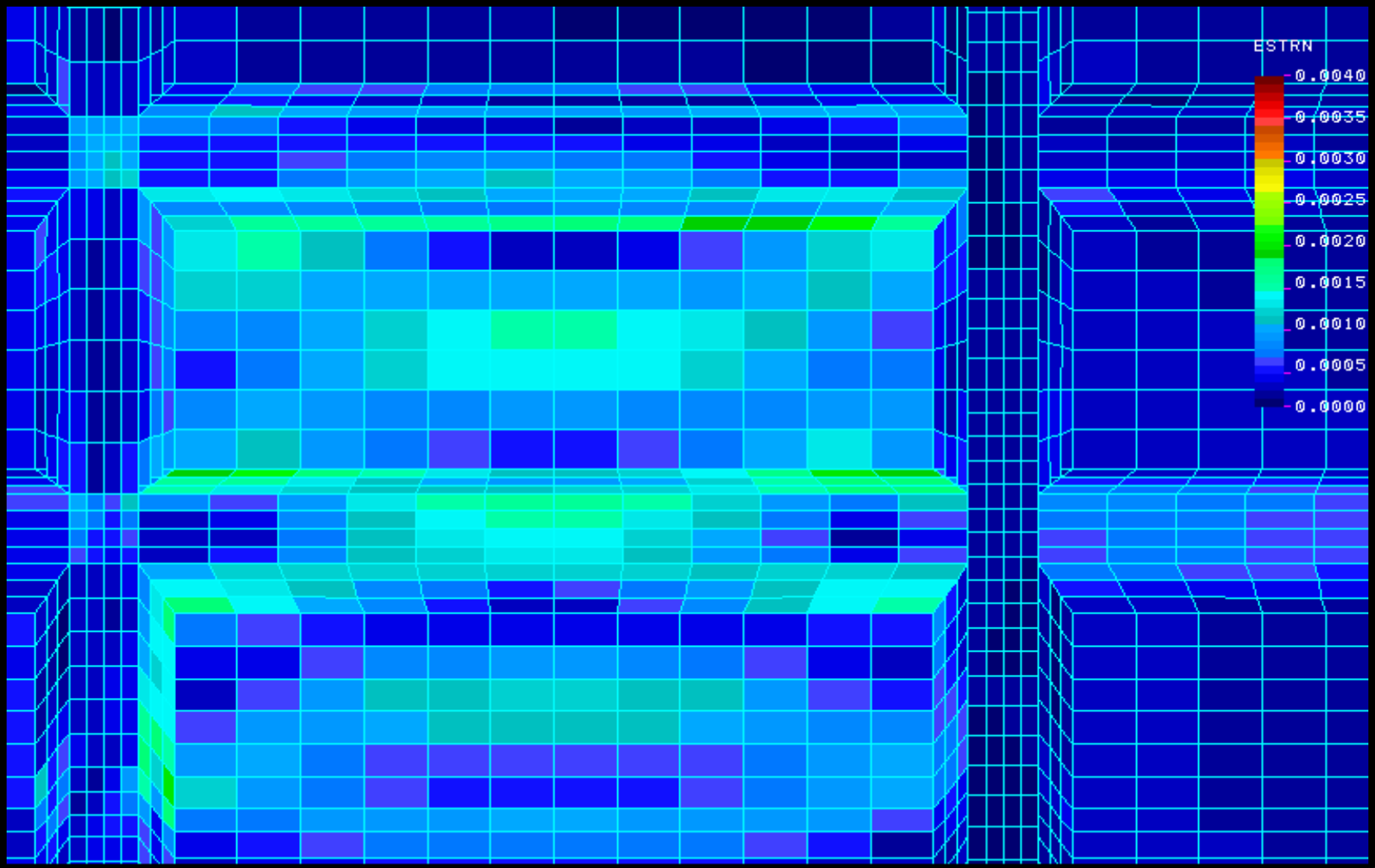
STRUCTURAL COMPOSITES ®

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LC1- AMI- Strain



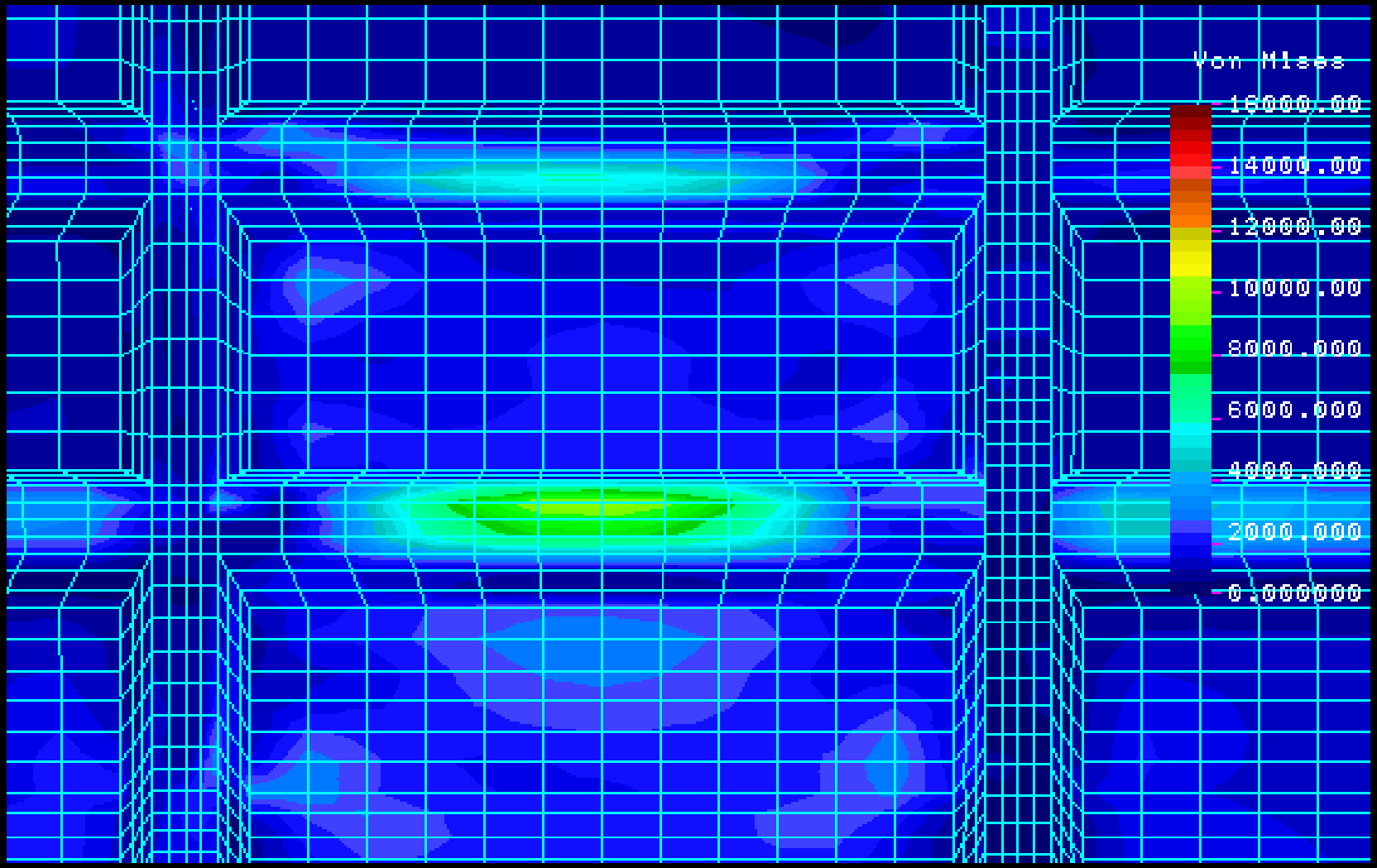
STRUCTURAL COMPOSITES ®

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LC1- AMI- Framing Stress



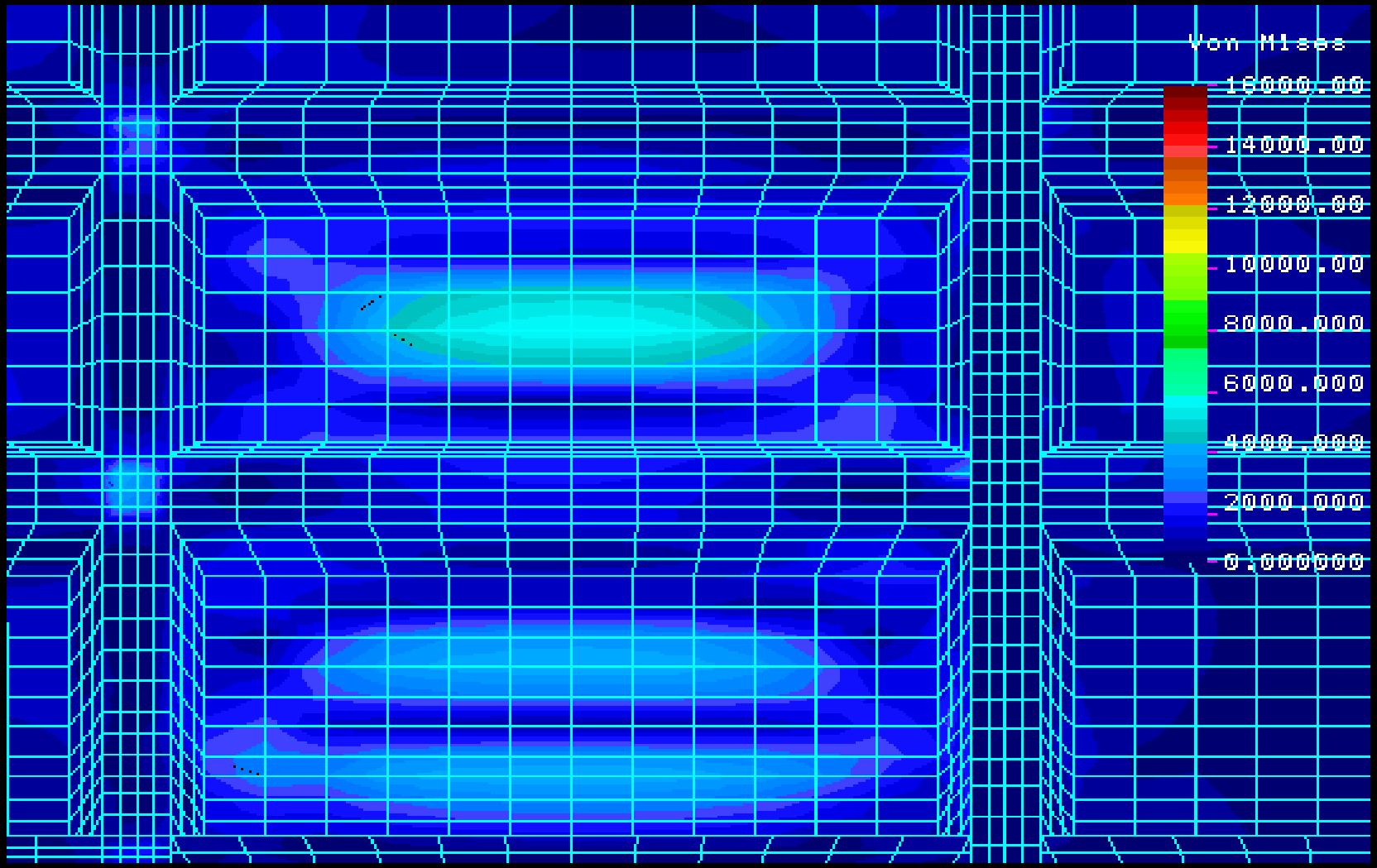
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LC1- Hull Shell Stress



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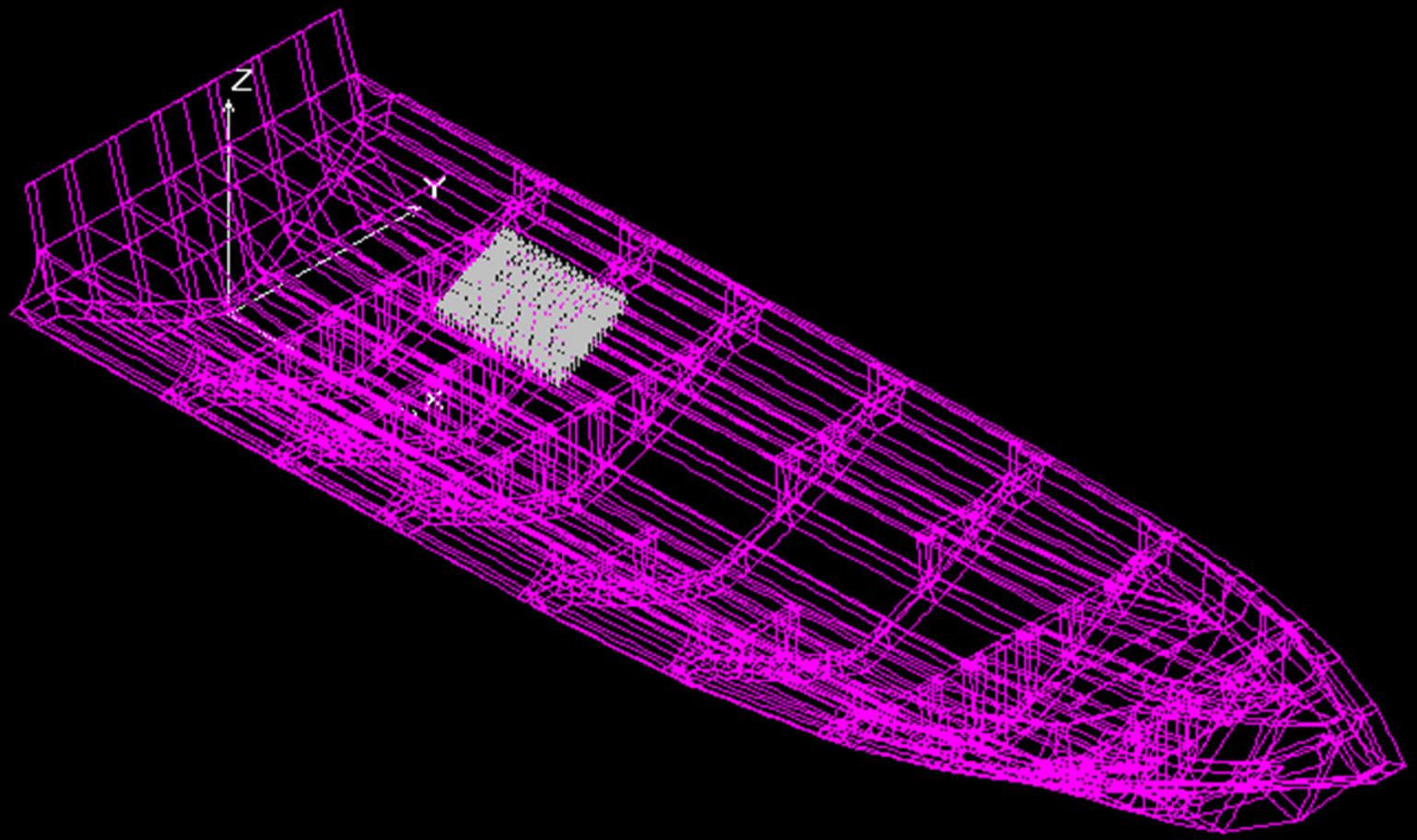
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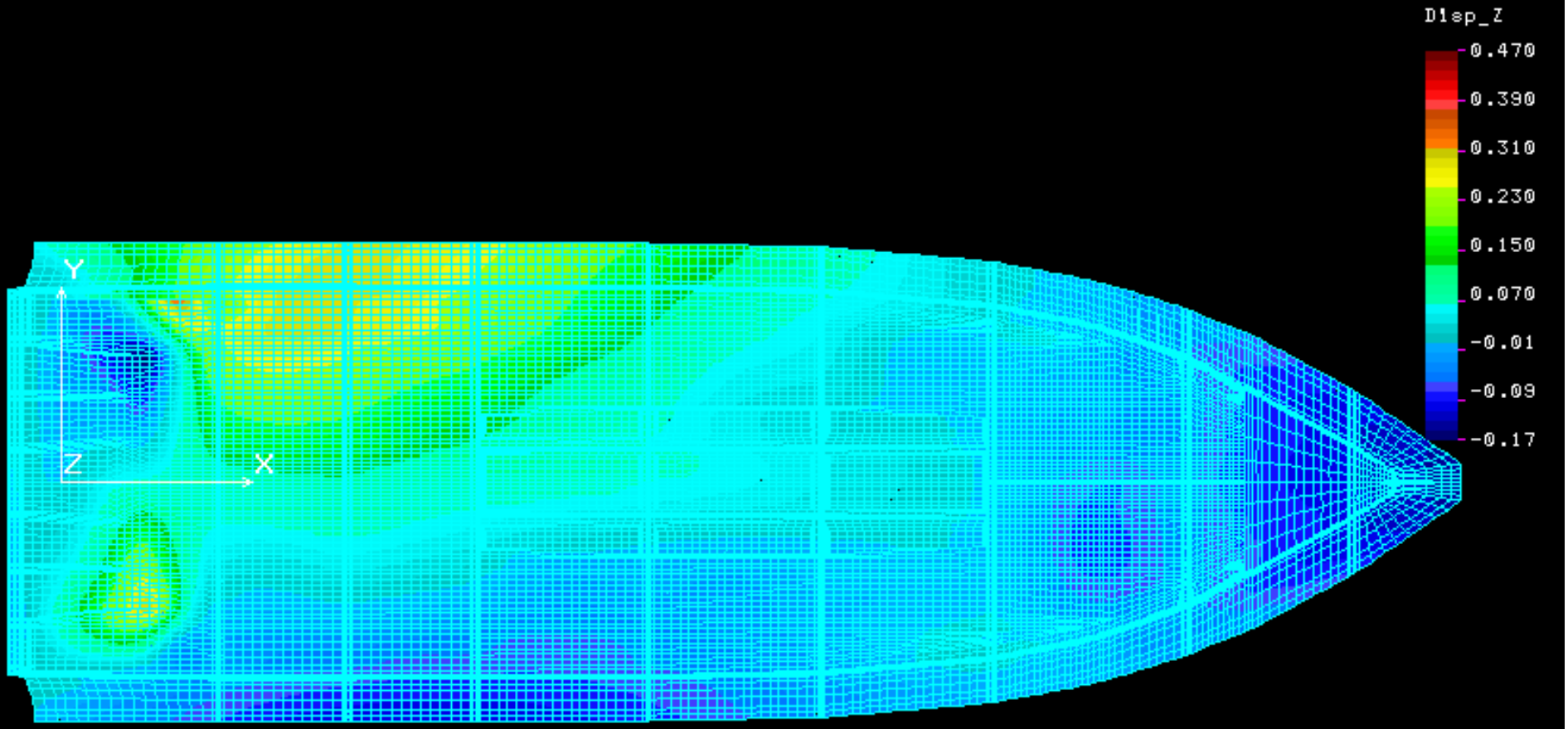
LC1- AMI- Summary

- Deck range of deflection 0.30 in.
- Hull range of deflection 0.44 in.
- Local panel deflection 0.165 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 9,000 psi
- Maximum hull shell stress 5,000 psi

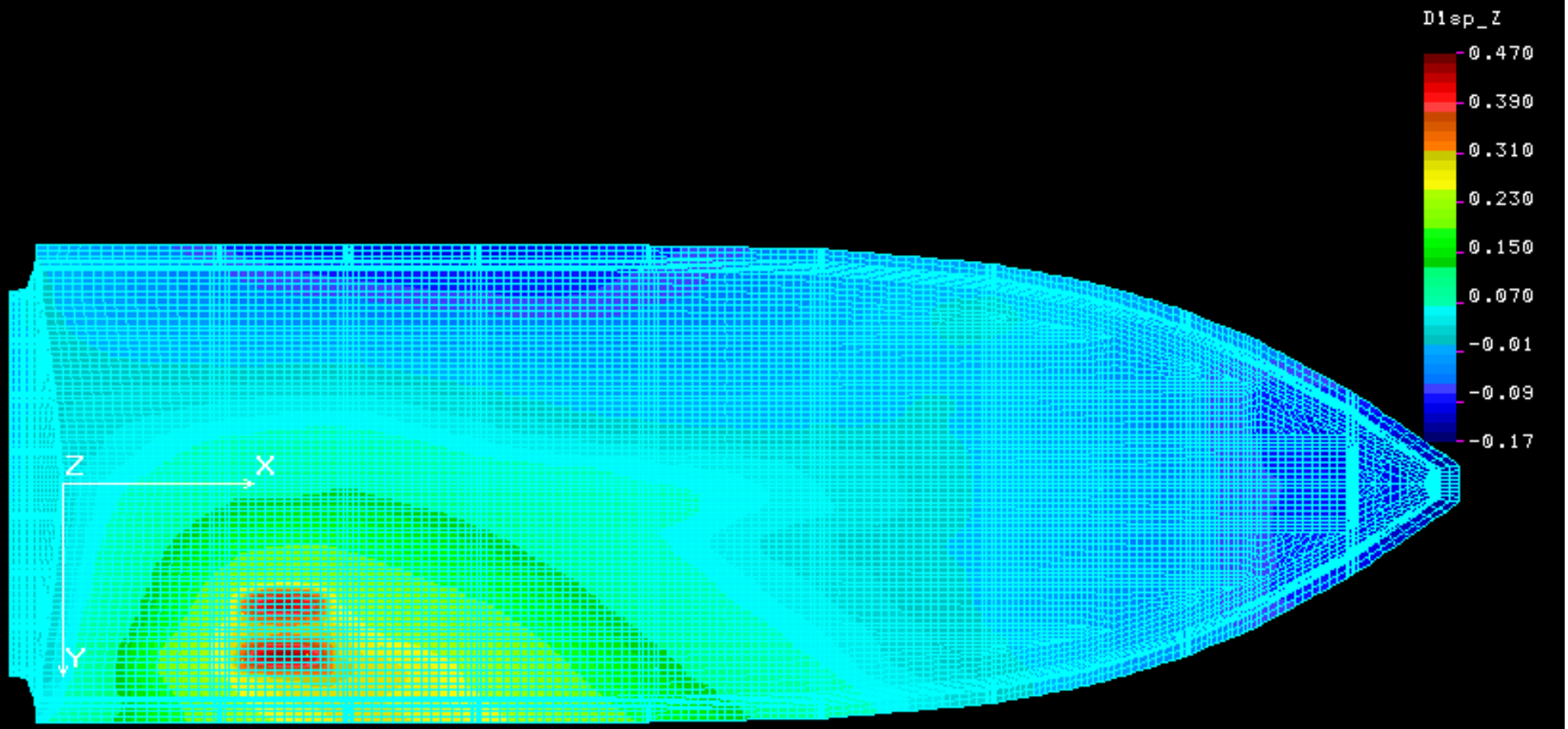
LC2- AMO-10 psi Pressure Load



LC2- AMO- Z Displacement- Deck

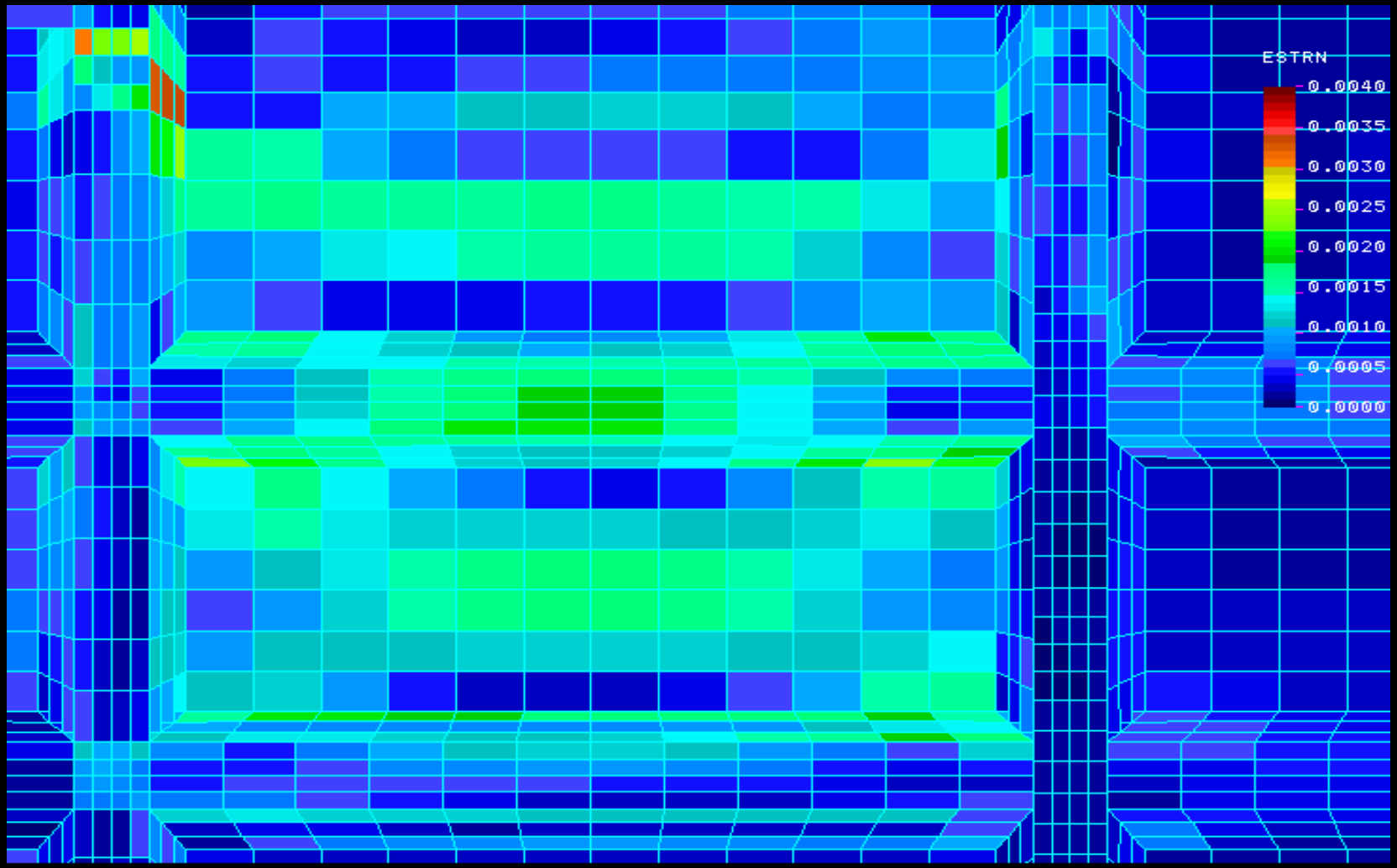


LC2- AMO- Z Displacement- Hull

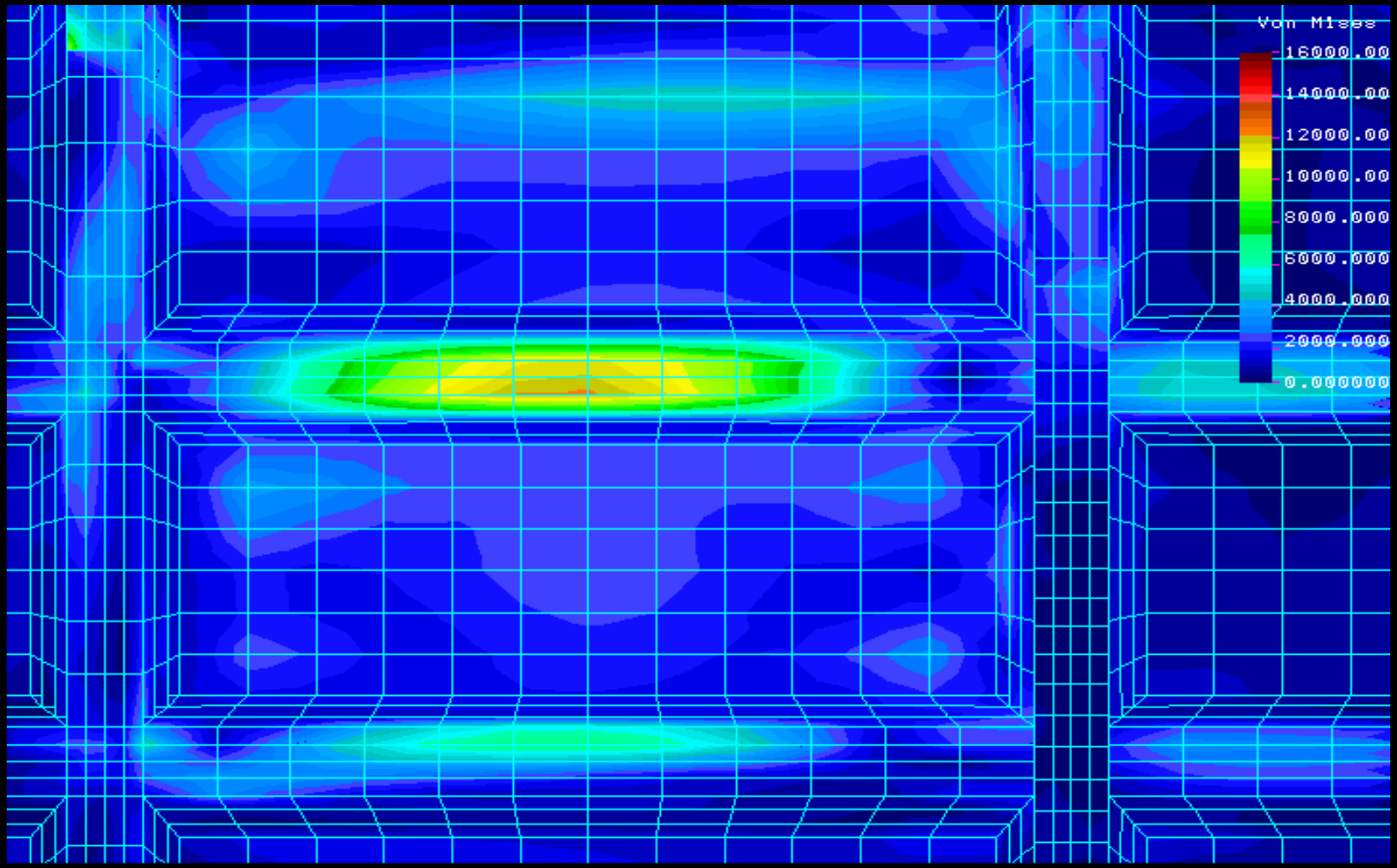


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LC2- AMO- Strain



LC2- AMO- Framing Stress



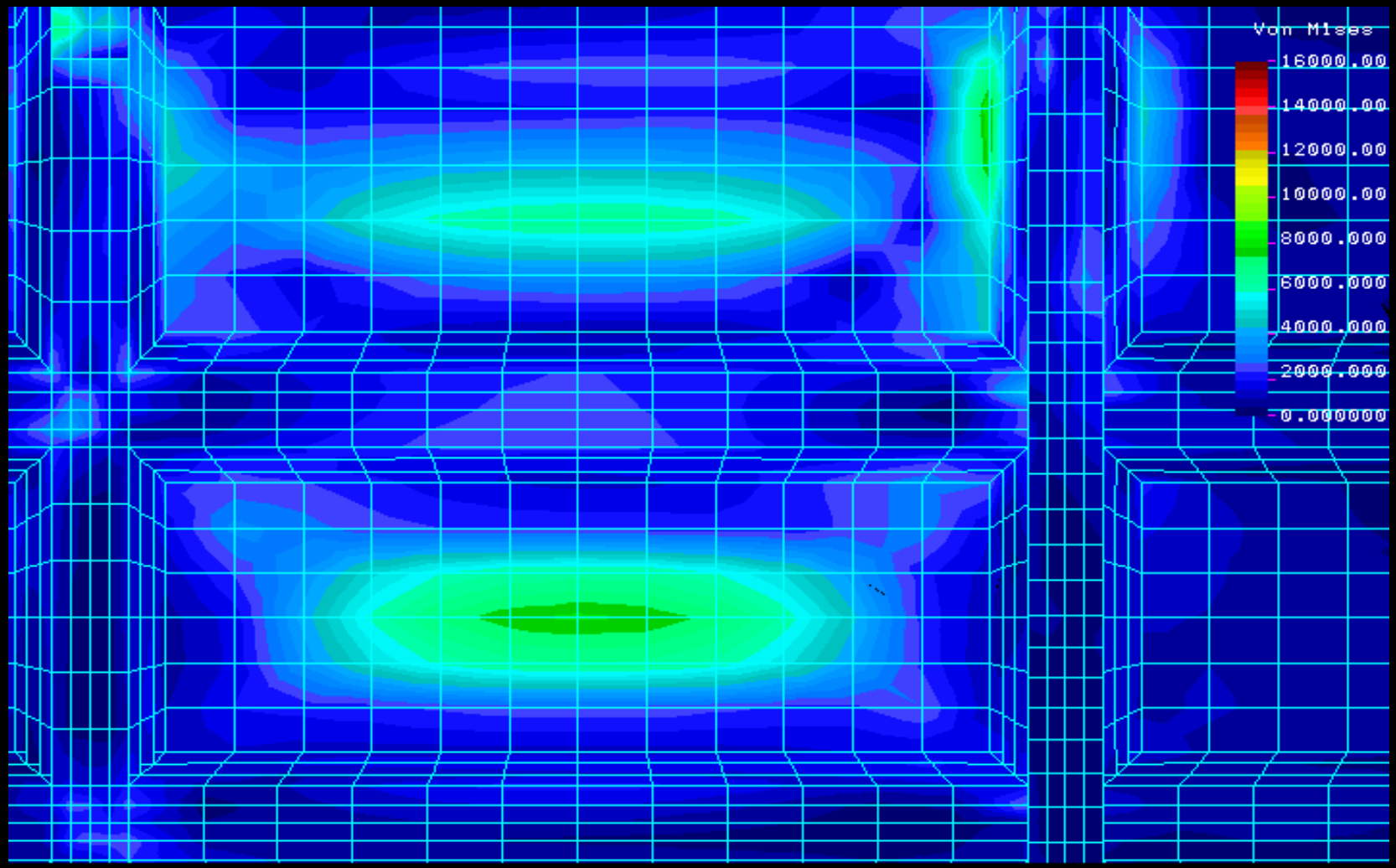
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LC2- AMO- Hull Shell Stress



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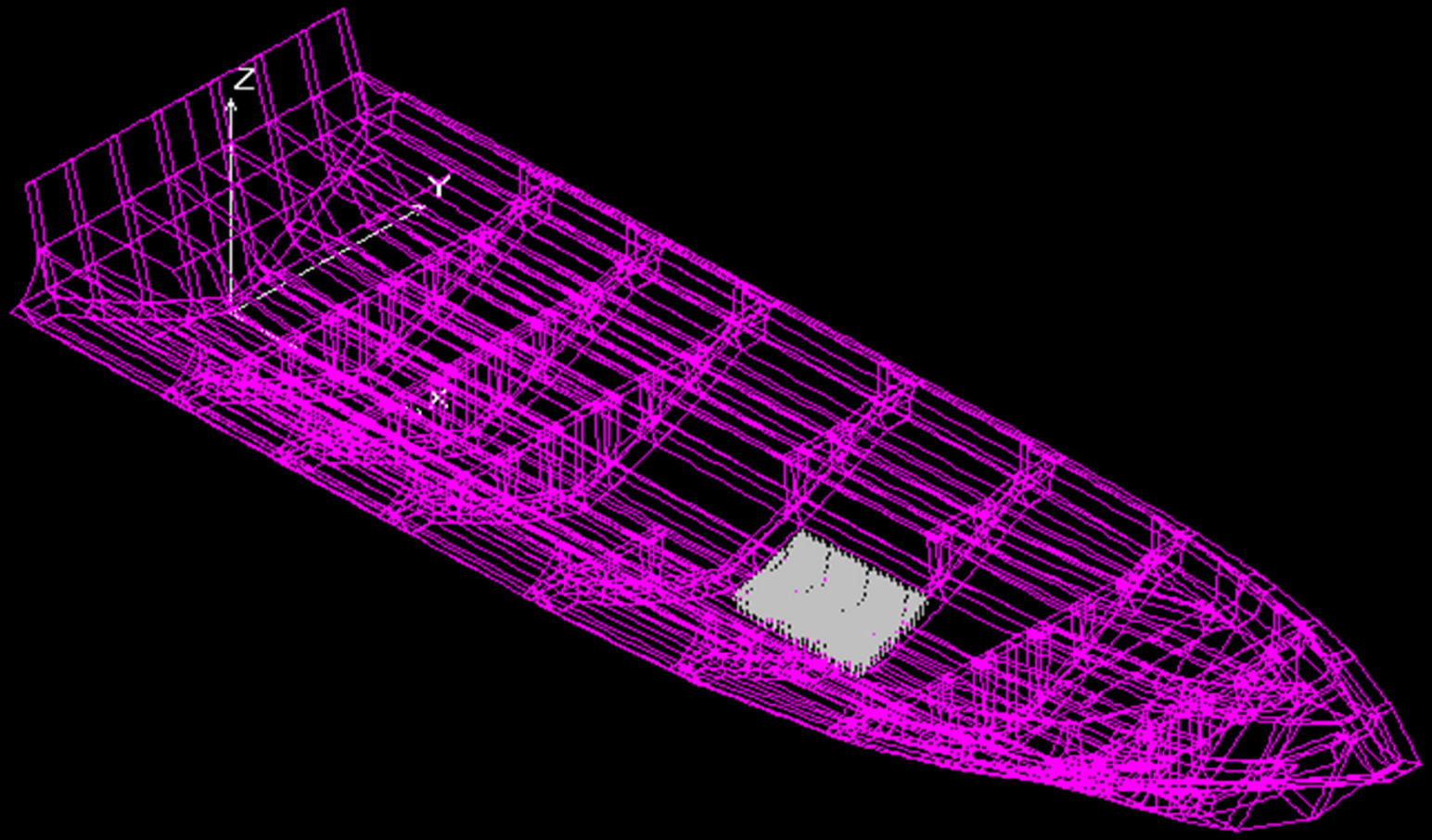
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LC2- AMO- Summary

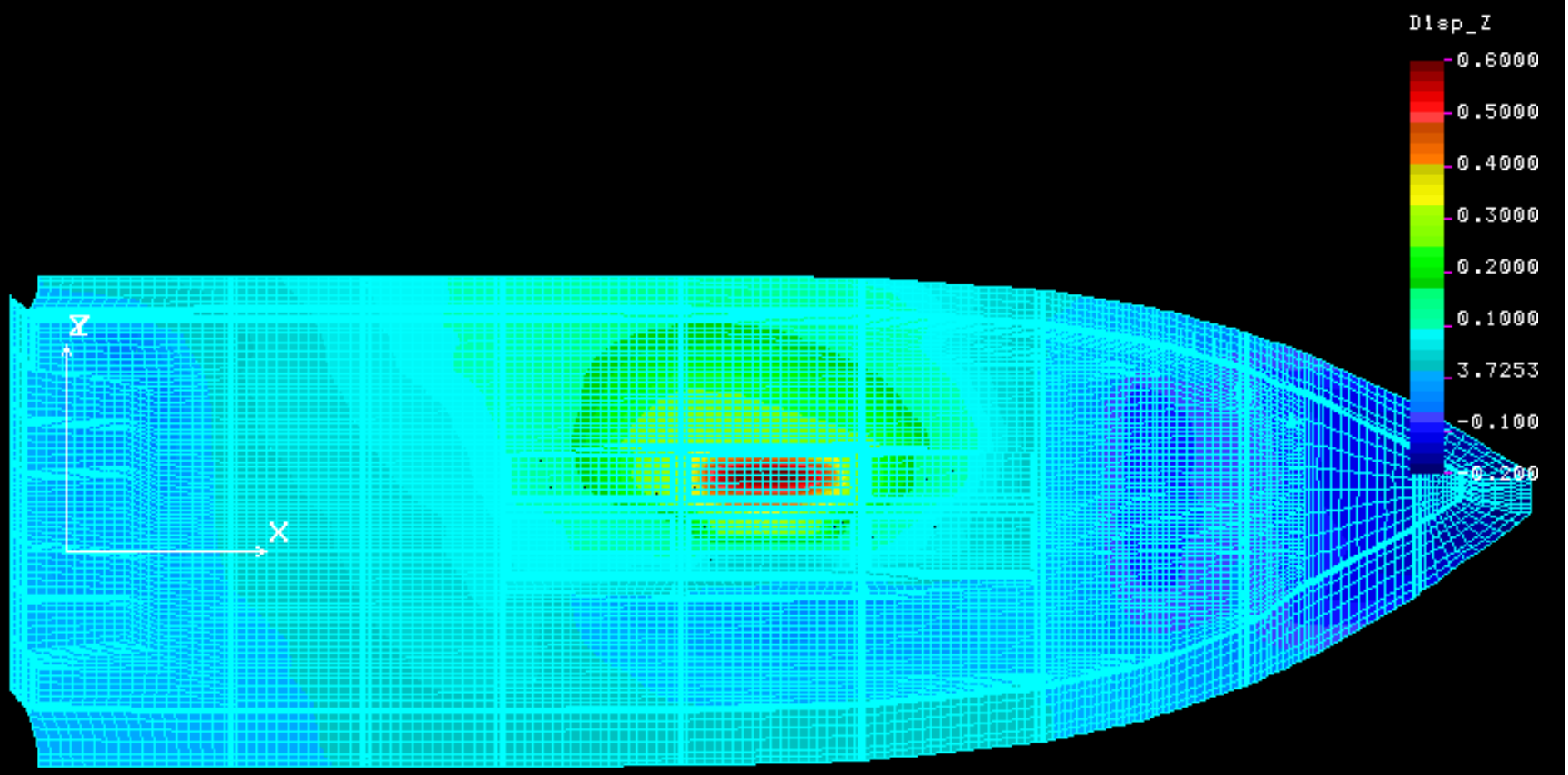
- Deck range of deflection 0.56 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.17 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 10,500 psi
- Maximum hull shell stress 7,000 psi

LC3- FI-10 psi Pressure Load



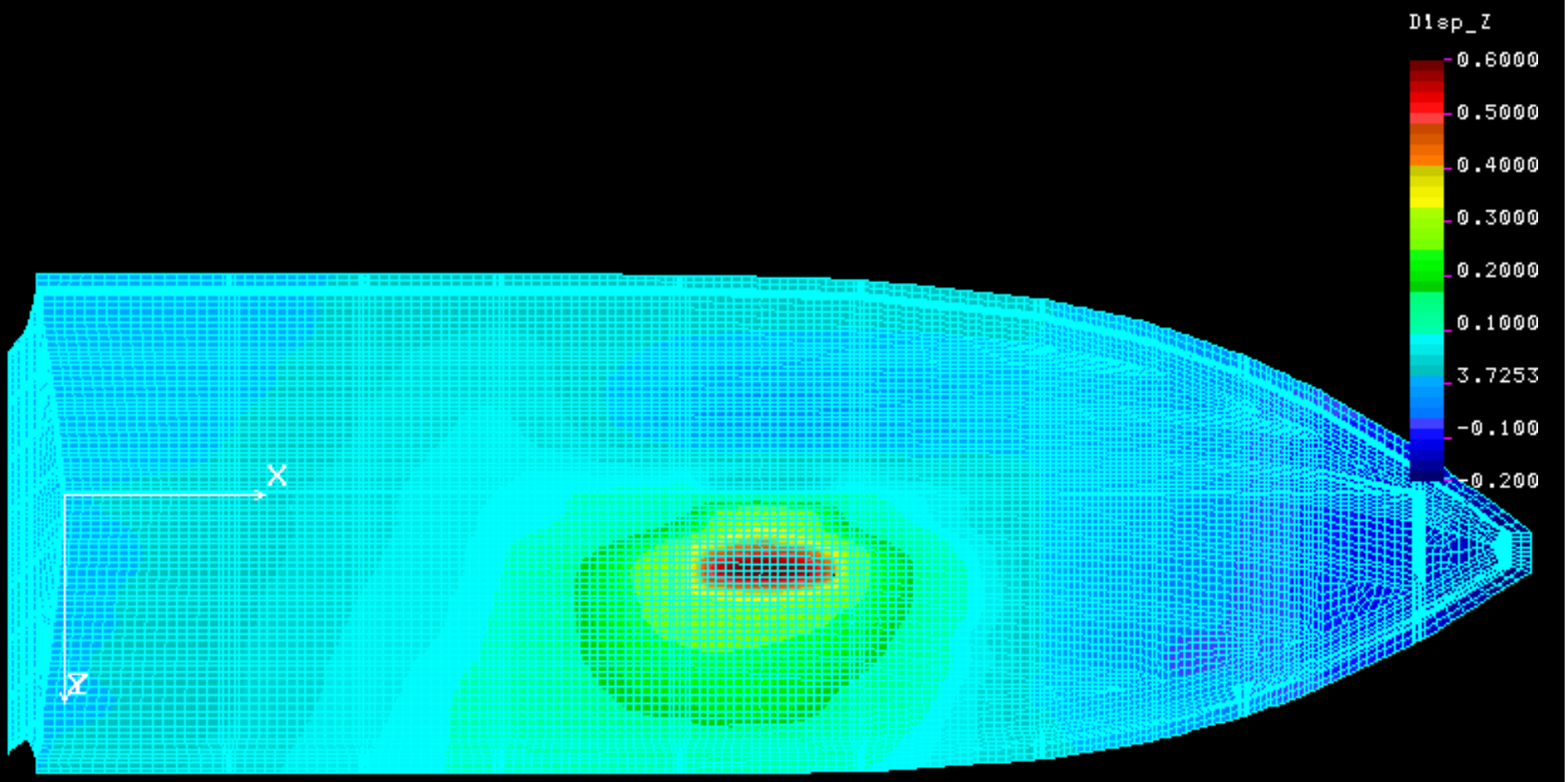
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LC3- FI- Z Displacement - Deck



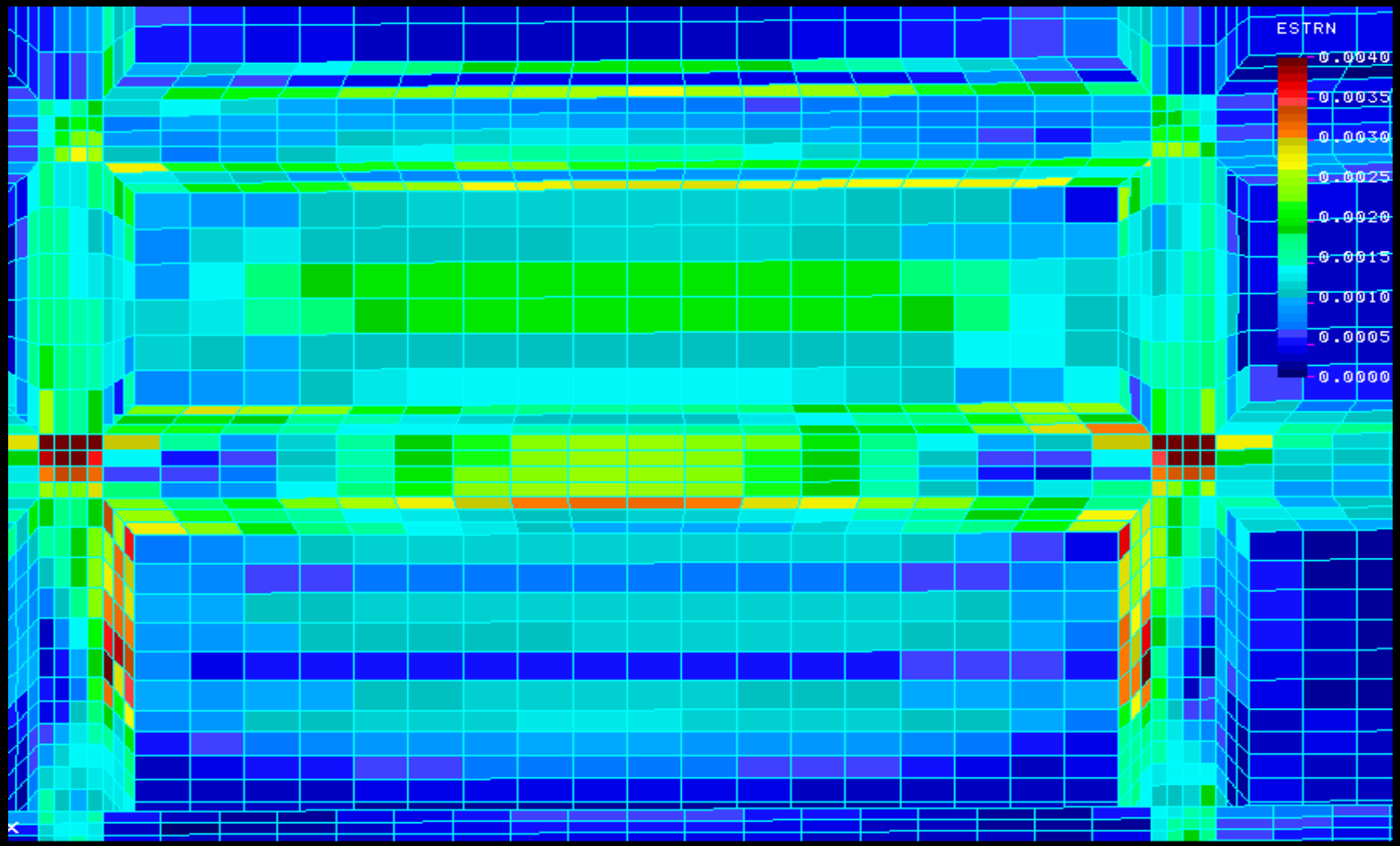
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LC3- FI- Z Displacement - Hull



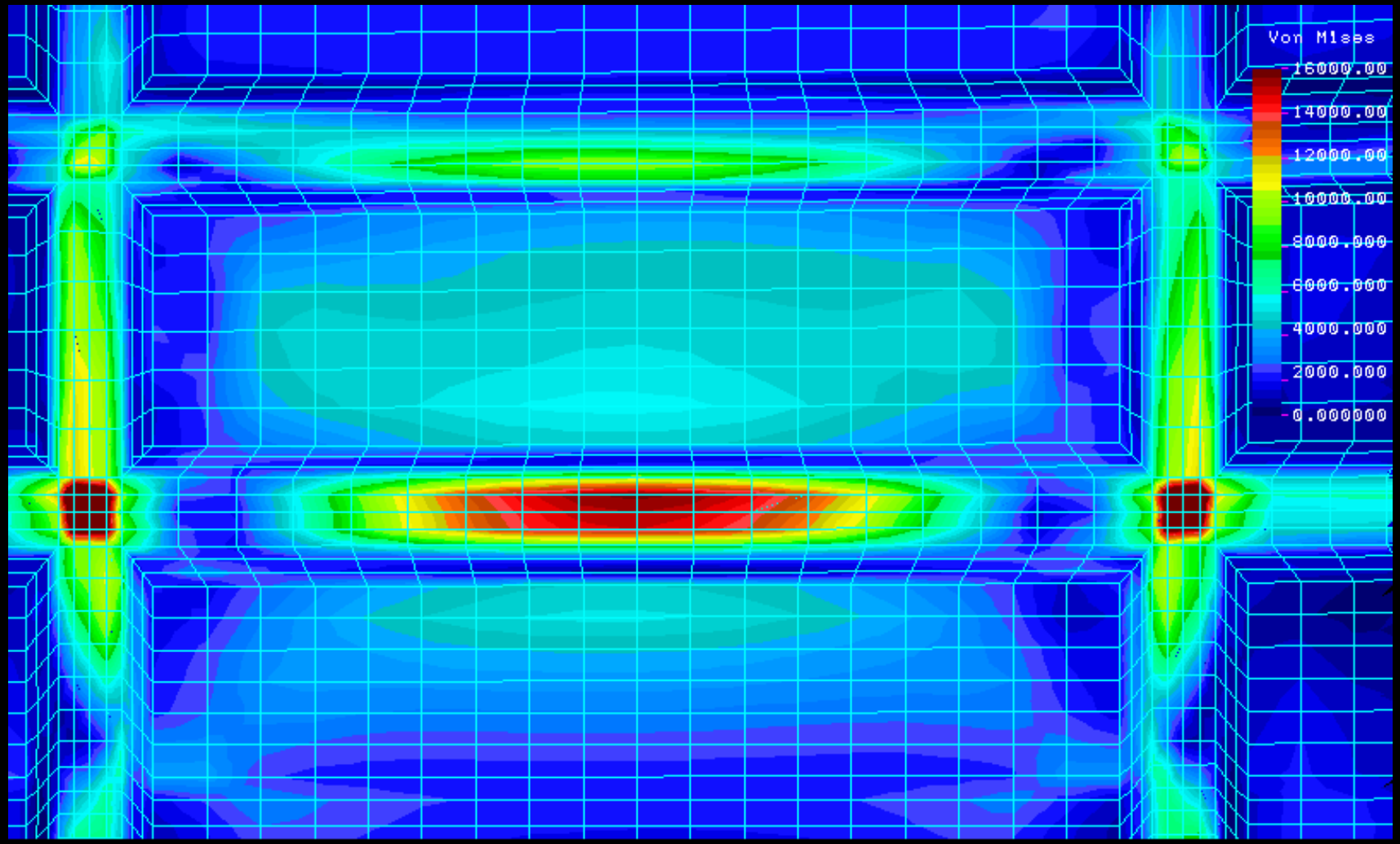
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LC3- FI- Strain



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LC3- FI- Framing Stress



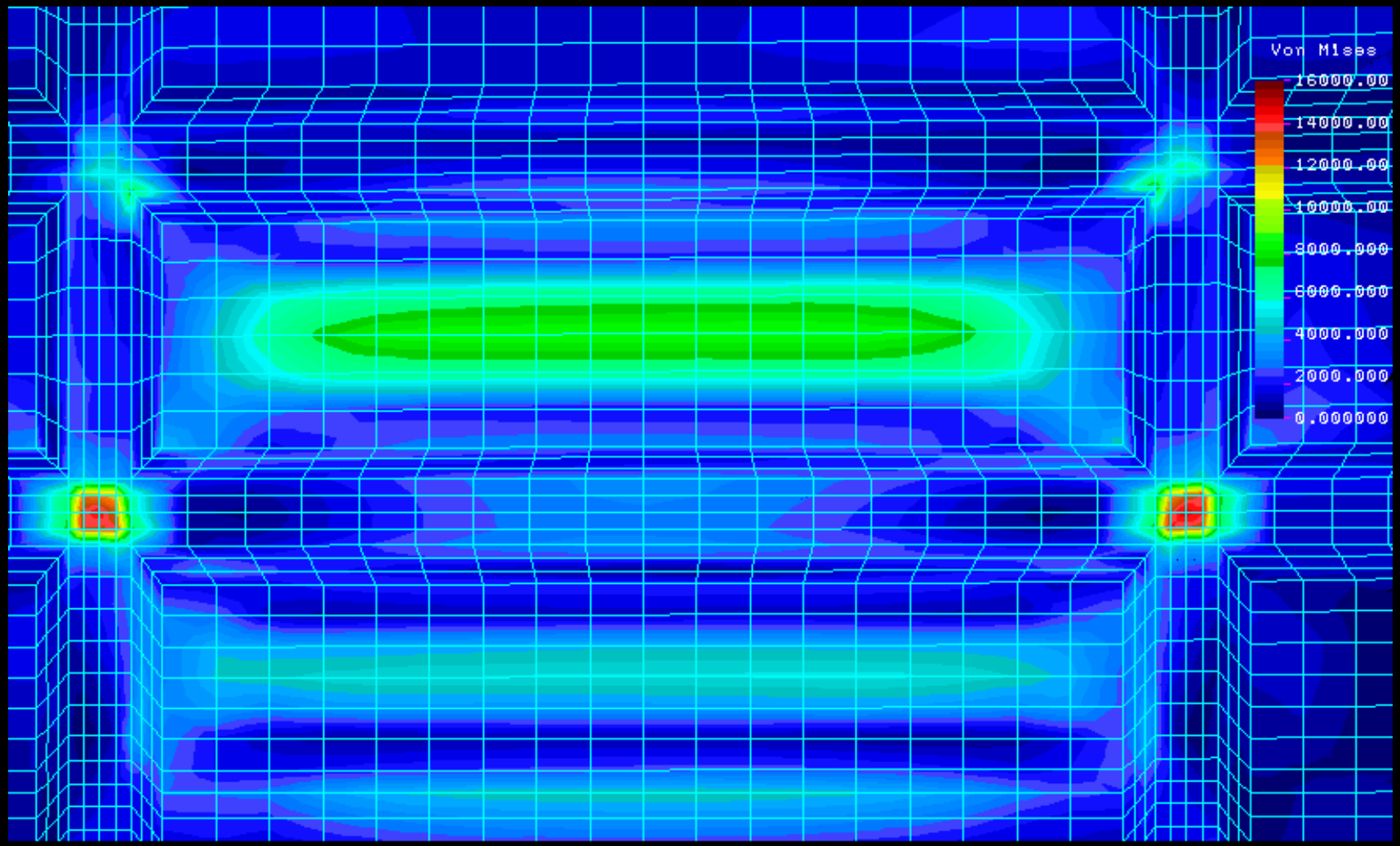
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LC3- FI- Hull Shell Stress



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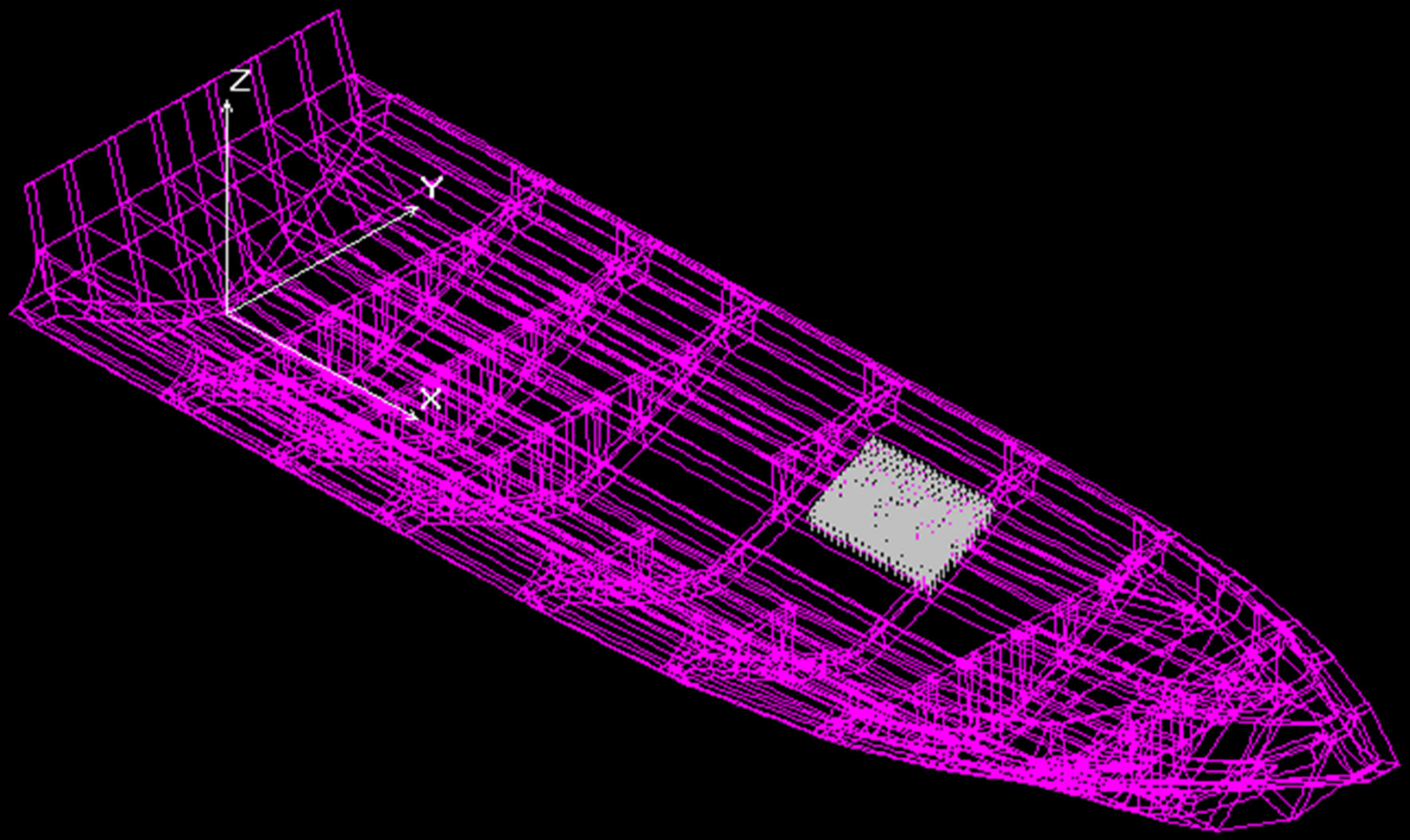
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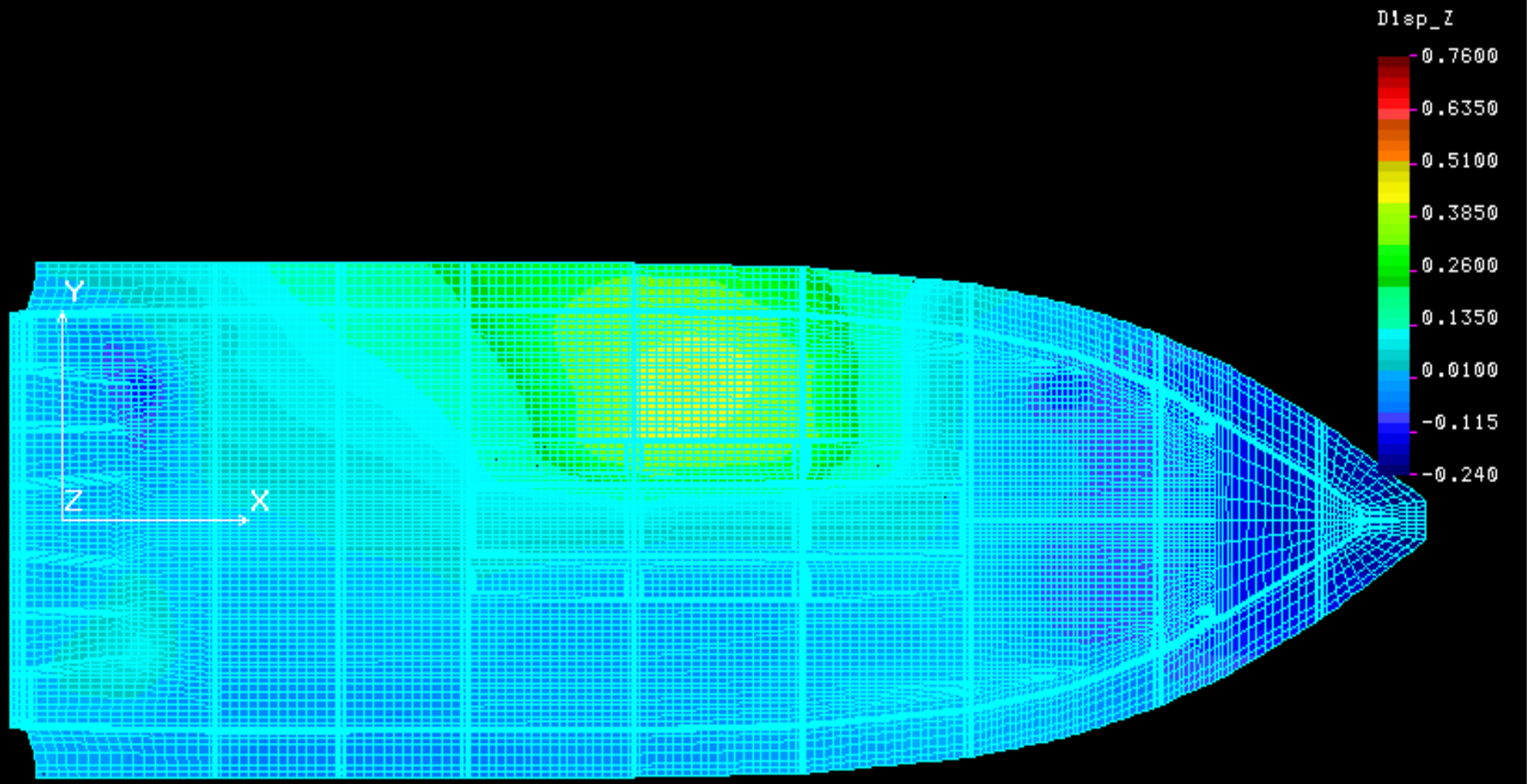
LC3- FI- Summary

- Deck range of deflection 0.8 in.
- Hull range of deflection 0.8 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC4- FO-10 psi Pressure Load

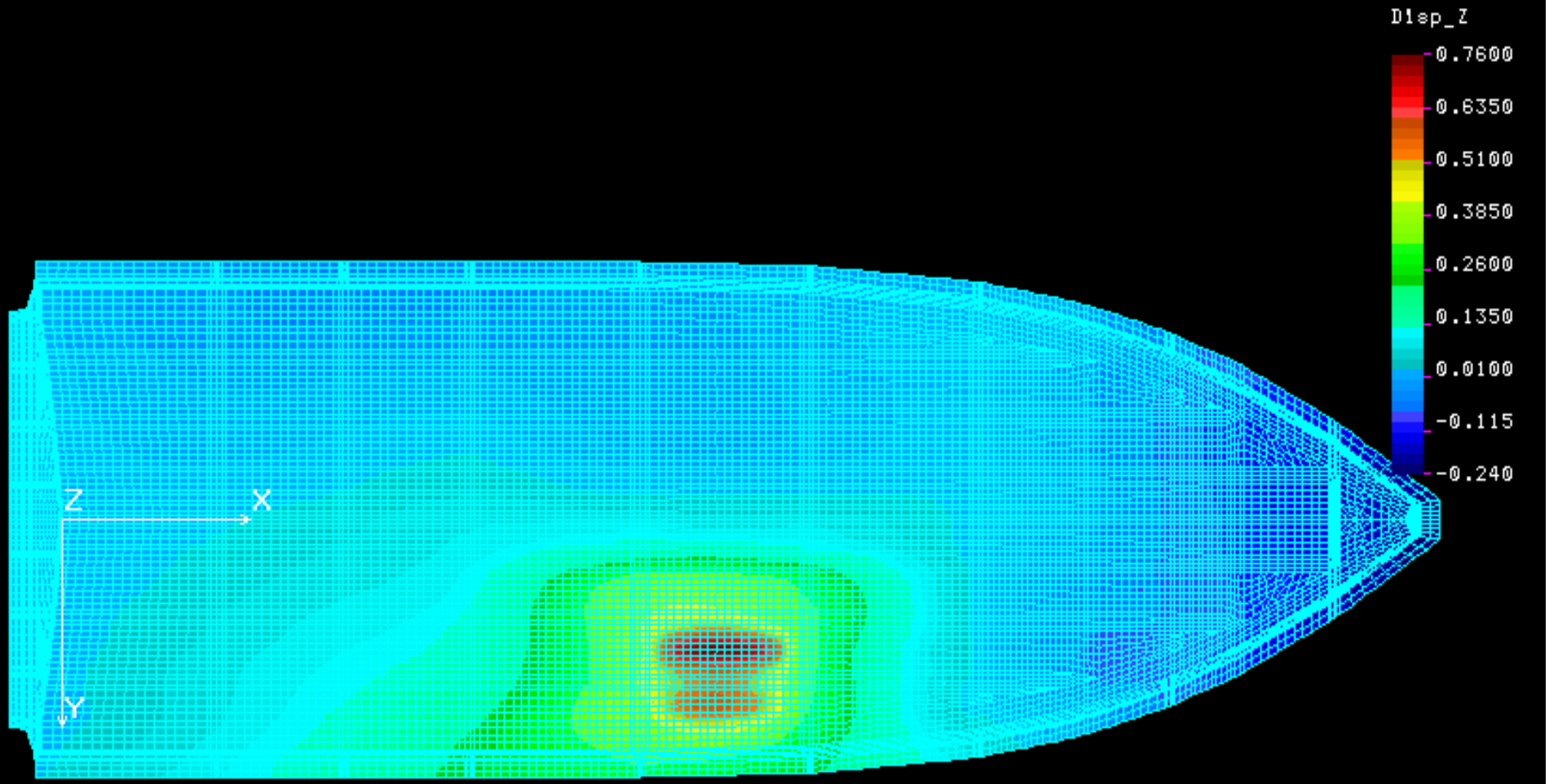


LC4- FO- Z Displacement- Deck



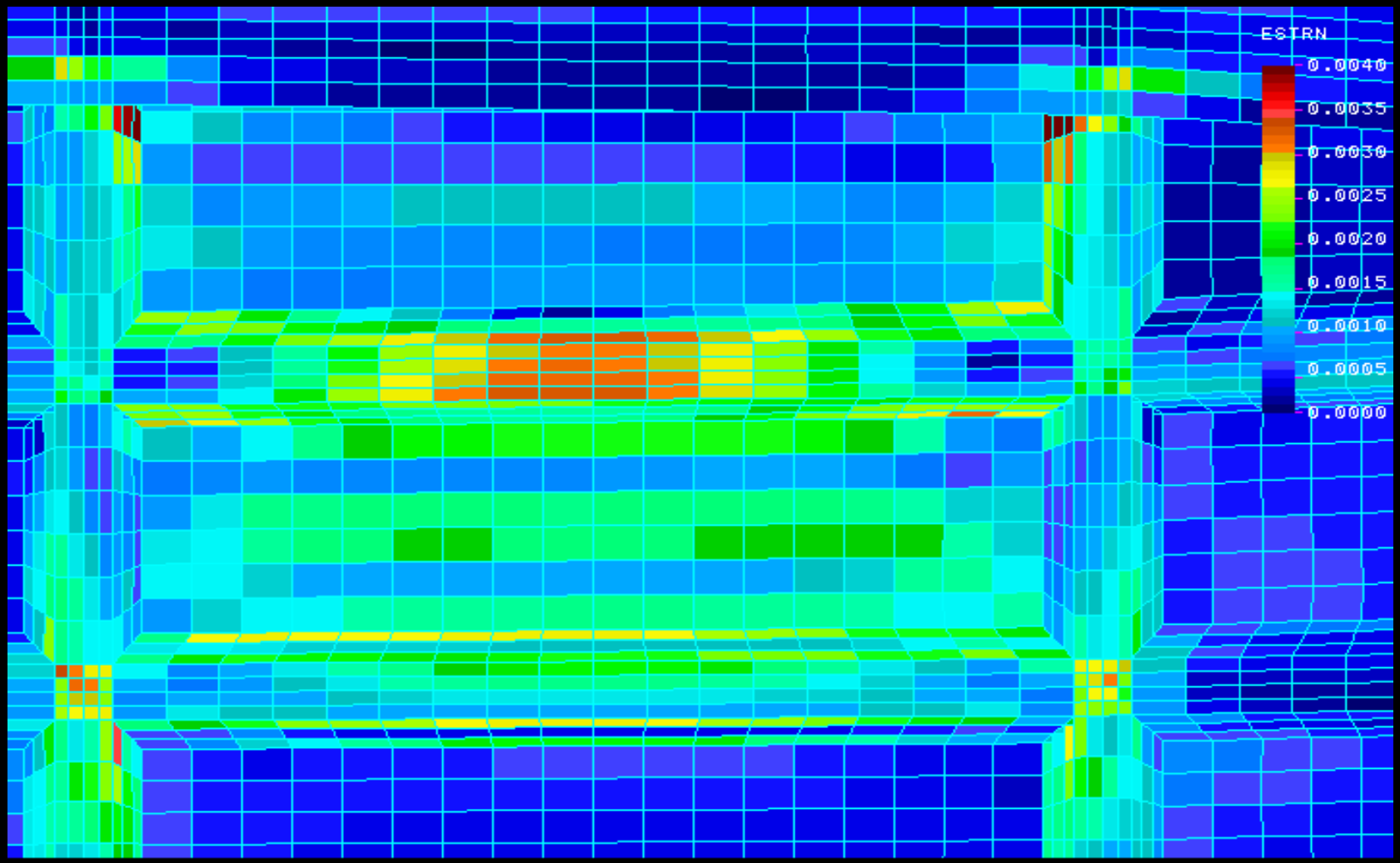
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LC4- FO- Z Displacement- Hull



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LC4- FO- Strain



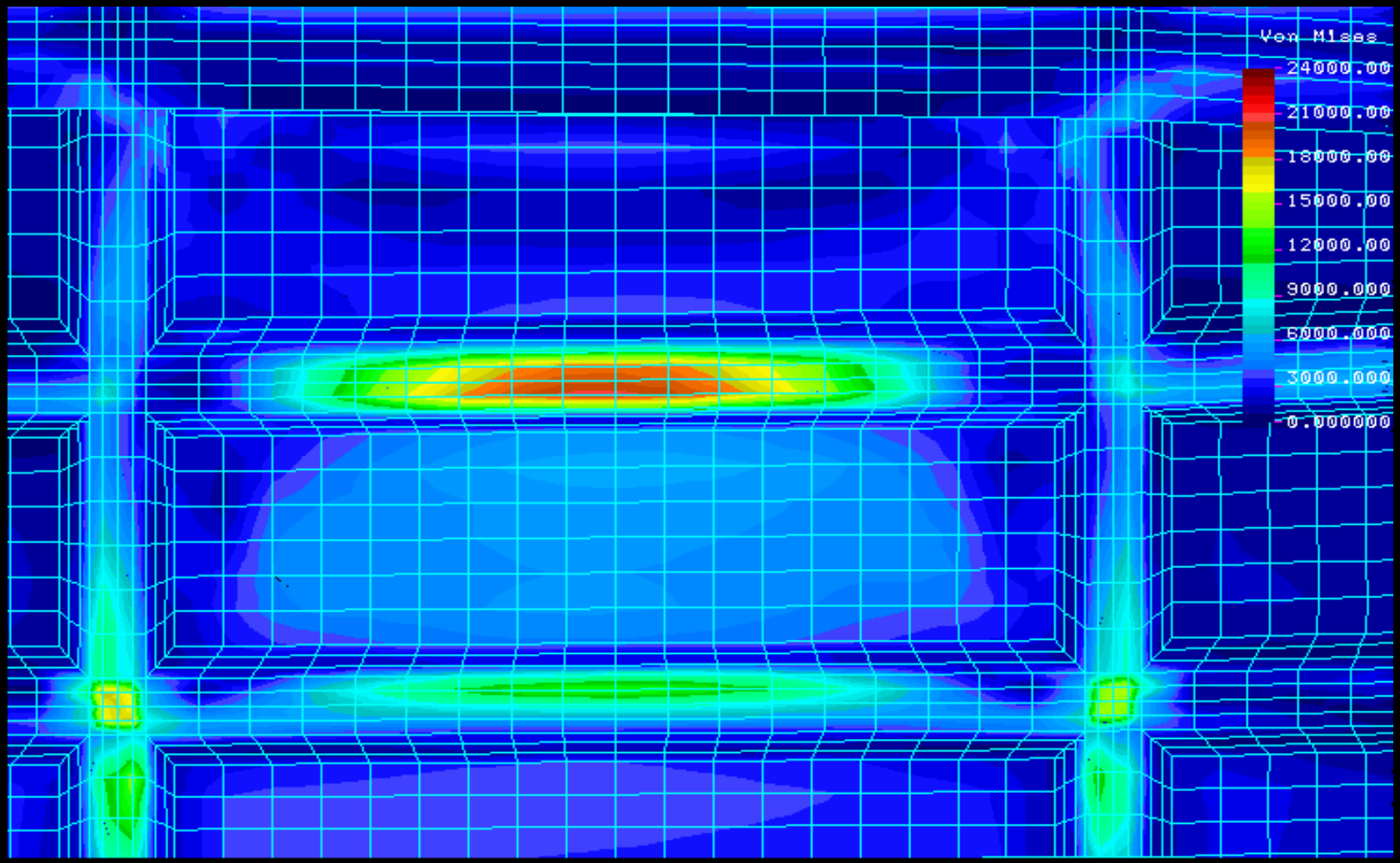
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LC4- FO- Framing Stress



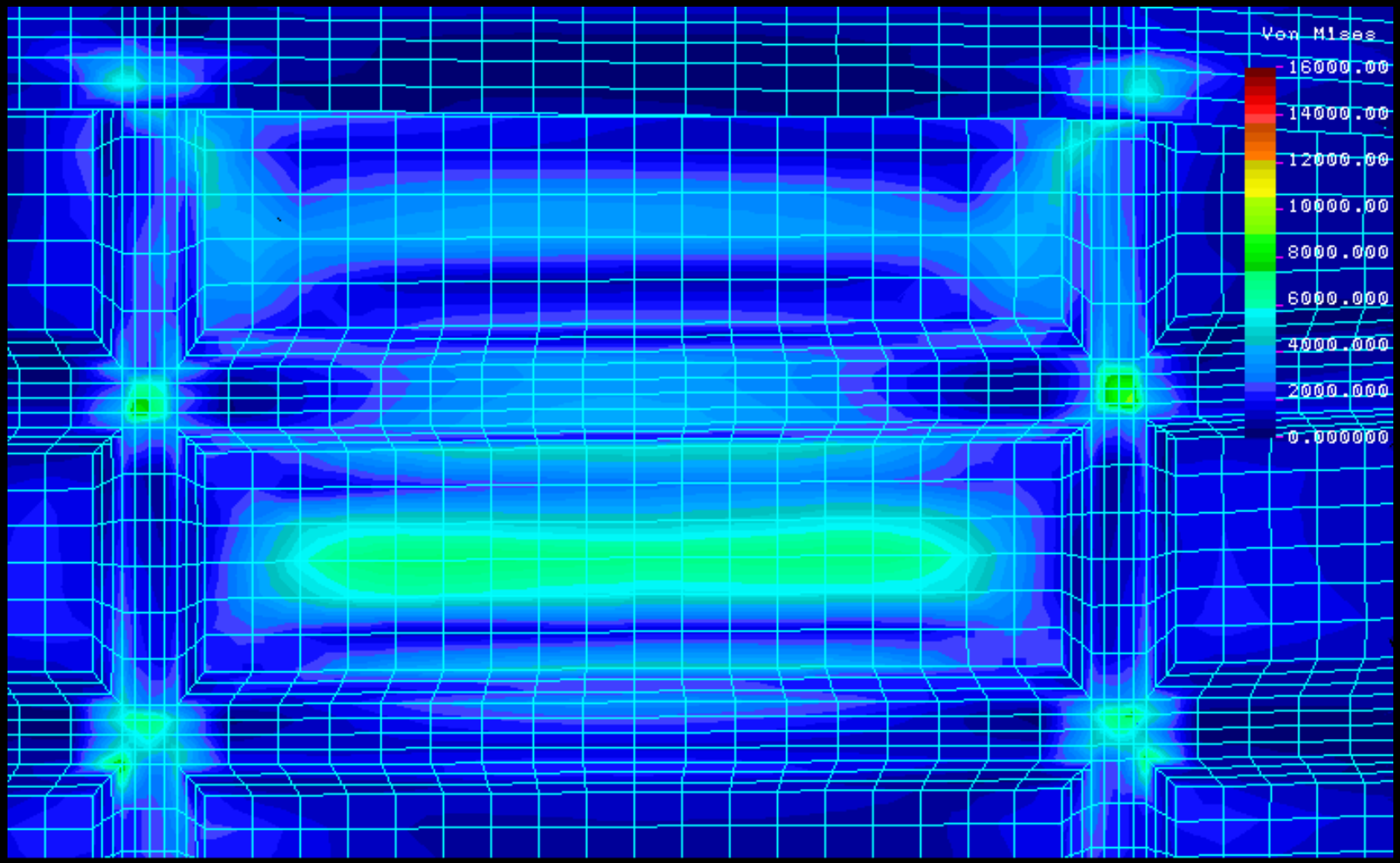
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LC4- FO- Hull Shell Stress



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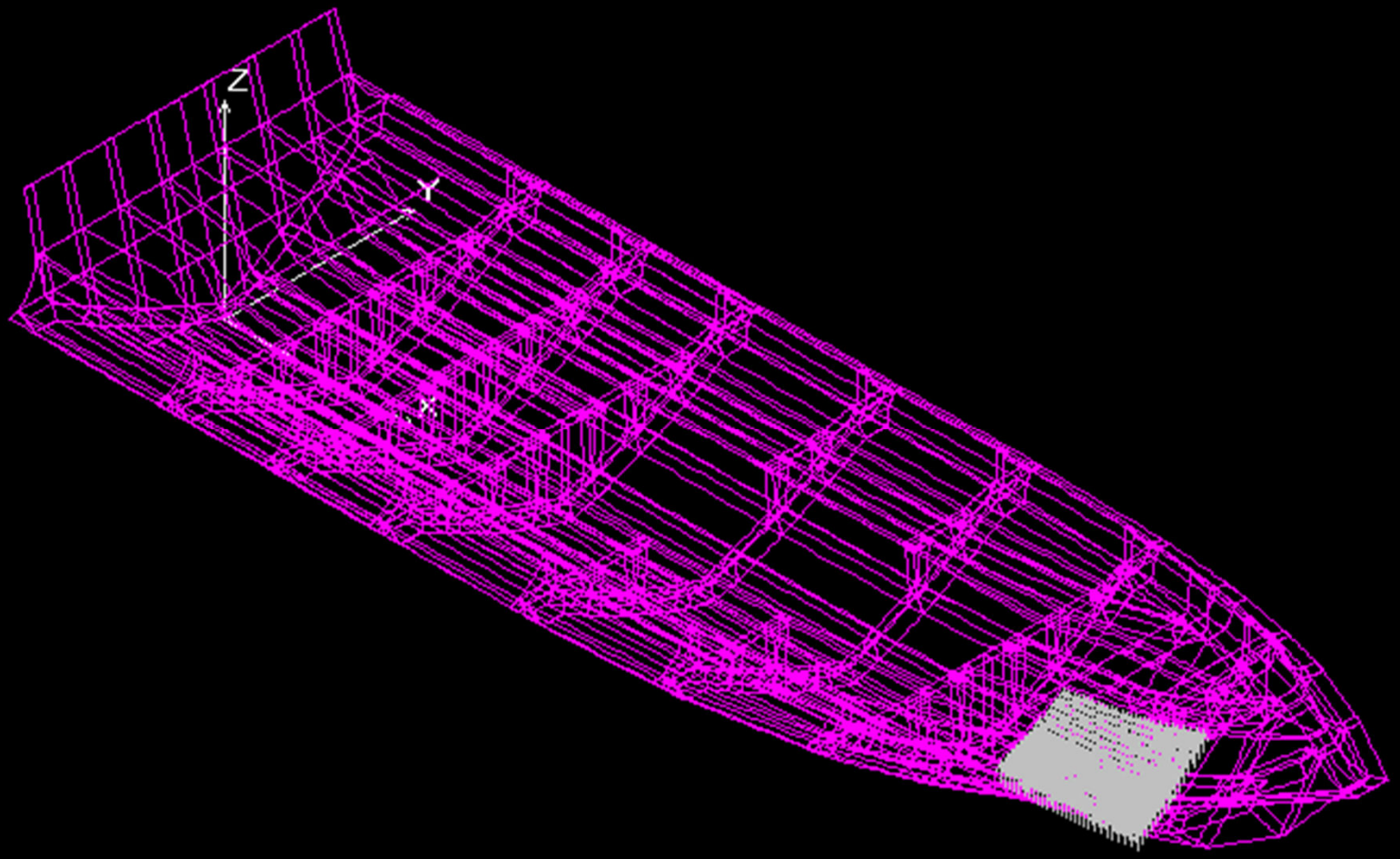
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LC4- FO- Summary

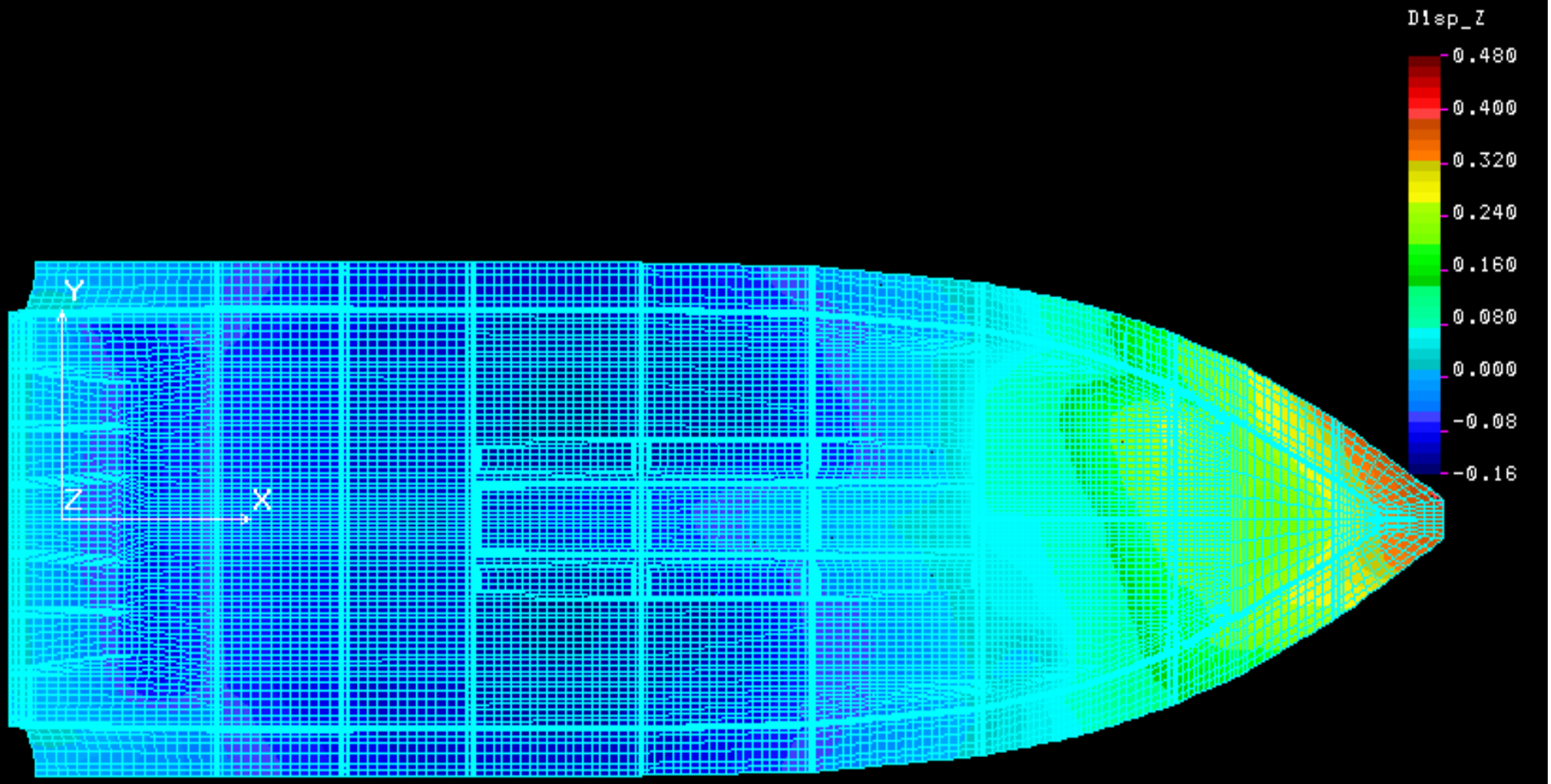
- Deck range of deflection 0.69 in.
- Hull range of deflection 1.0 in.
- Local panel deflection 0.36 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 19,000 psi
- Maximum hull shell stress 5,500 psi

LC5- STR-10 psi Pressure Load



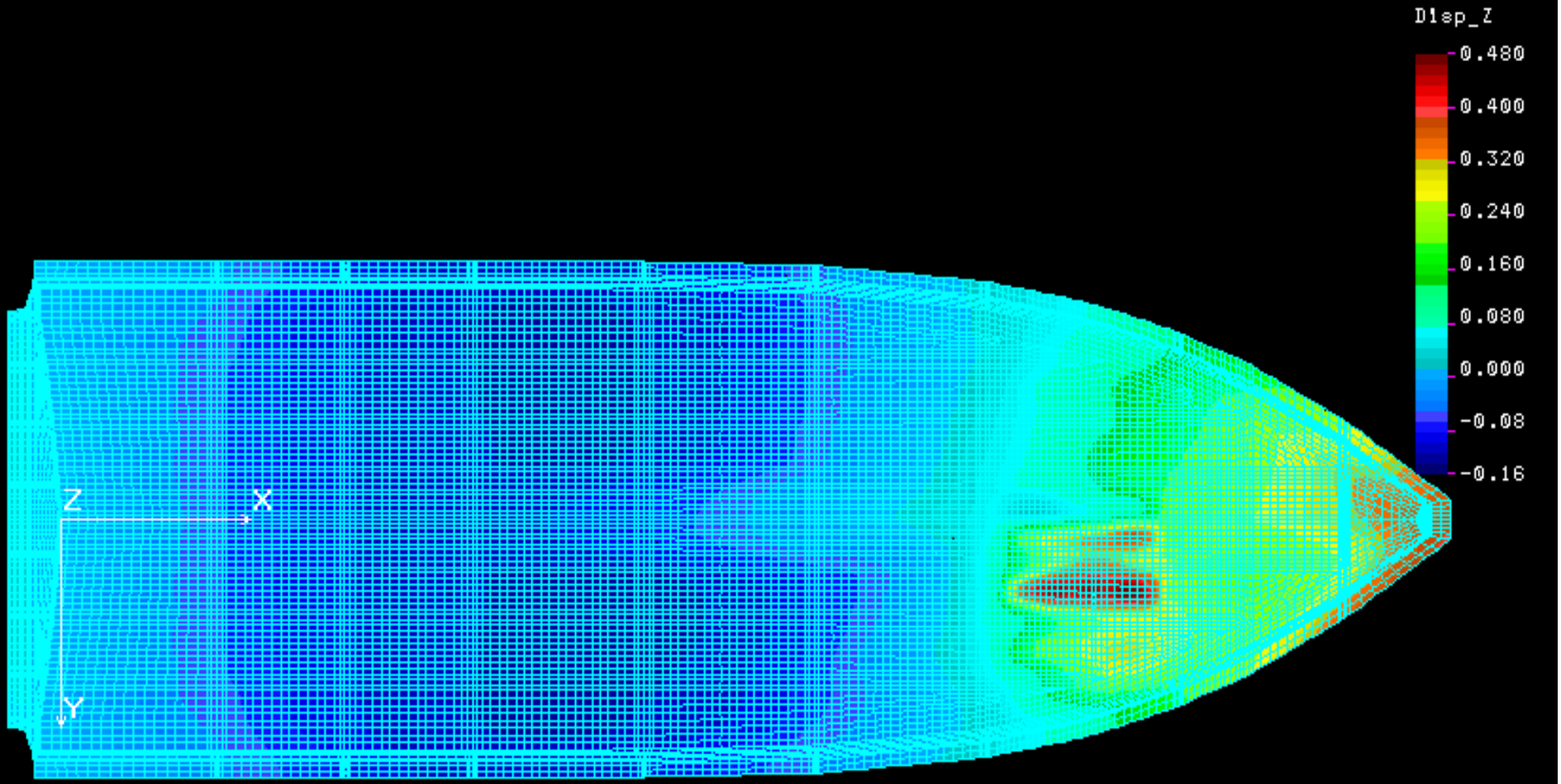
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LC5- STR- Z Displacement - Deck



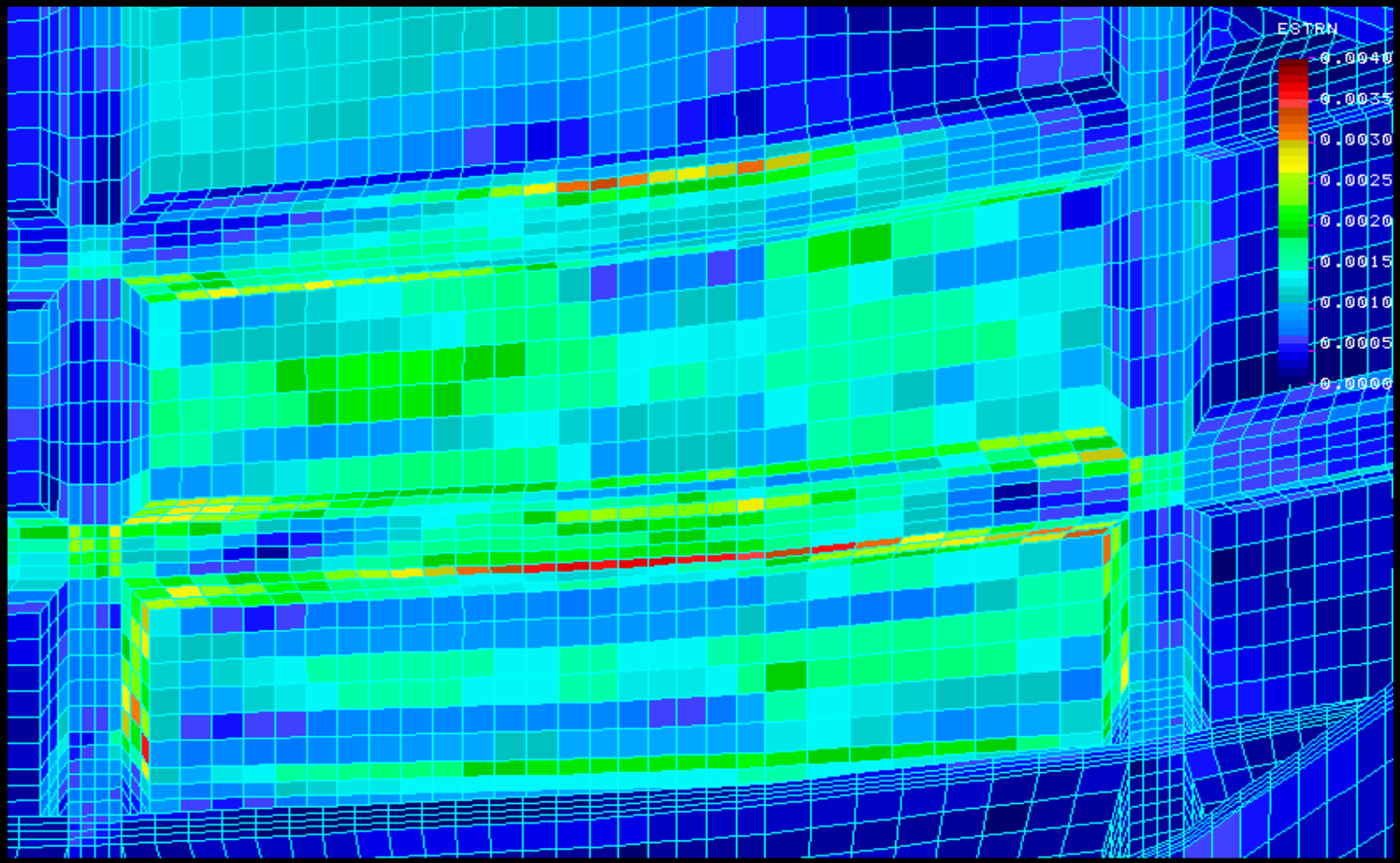
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LC5- STR- Z Displacement - Hull



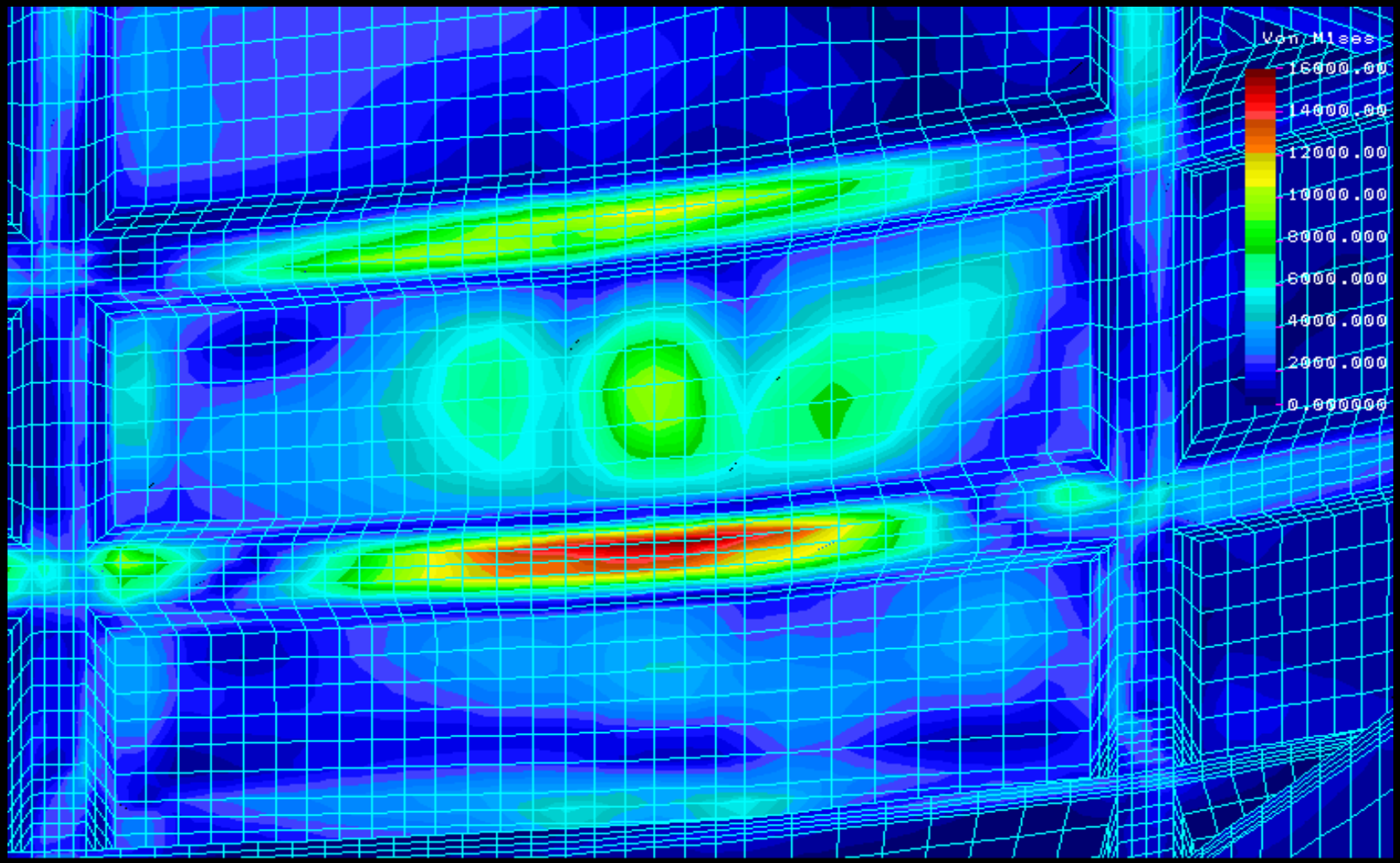
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LC5- STR- Strain



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LC5- STR- Framing Stress



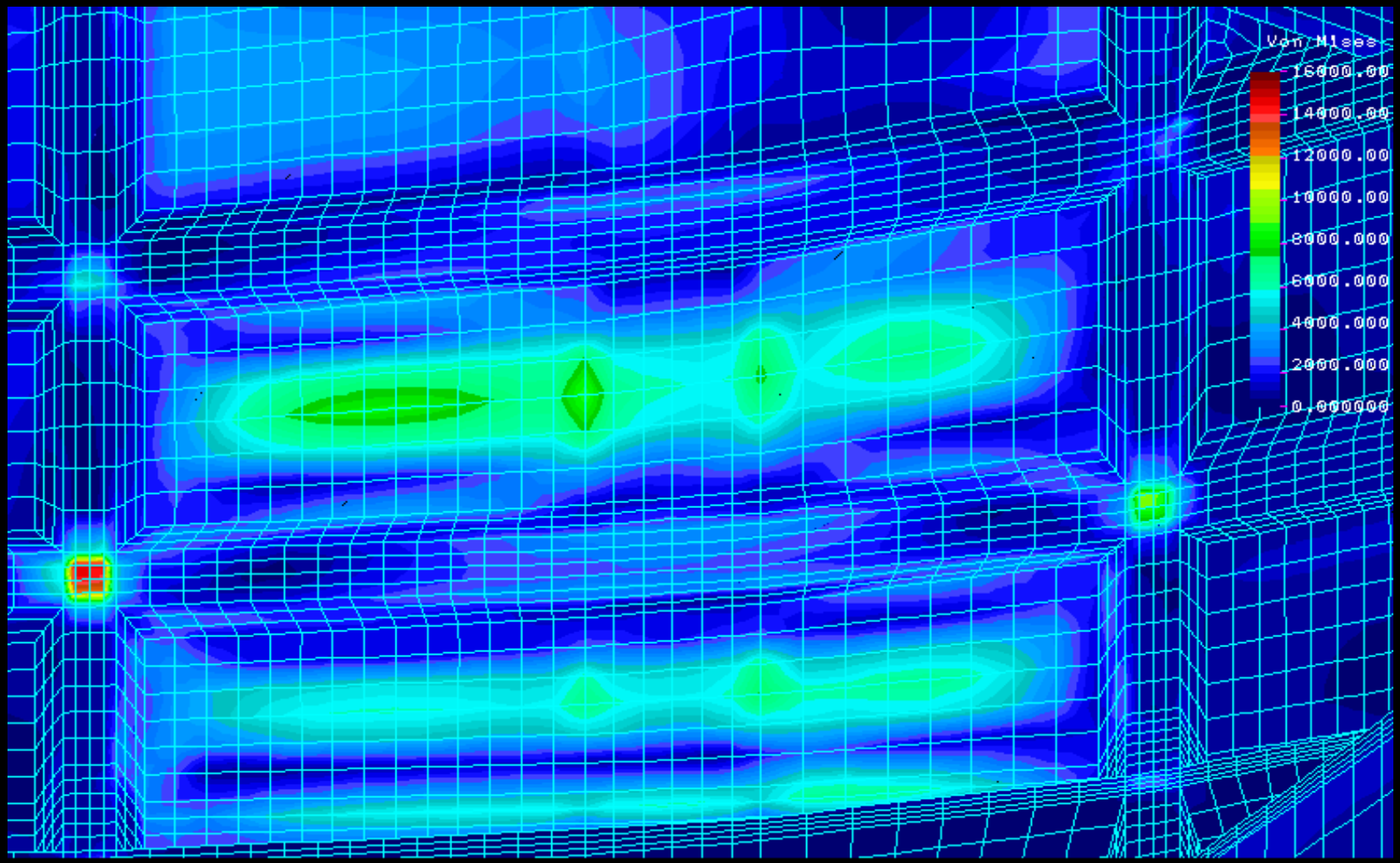
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LC5- STR- Hull Shell Stress



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LC5- STR- Summary

- Deck range of deflection 0.52 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0035 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC(1-5)- SAS Summary

Range of maximum values in SAS cases

- Deck range of deflection 0.30-0.69 in.
- Hull range of deflection 0.44-1.0 in.
- Local panel deflection 0.16-0.36 in.
- Maximum strain 0.002-0.0035 in/in
- Maximum framing stress 9,000-19,000 psi
- Maximum hull shell stress 5,000-8,000 psi

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850A- FEA Analysis: Large Area Slam (LAS)







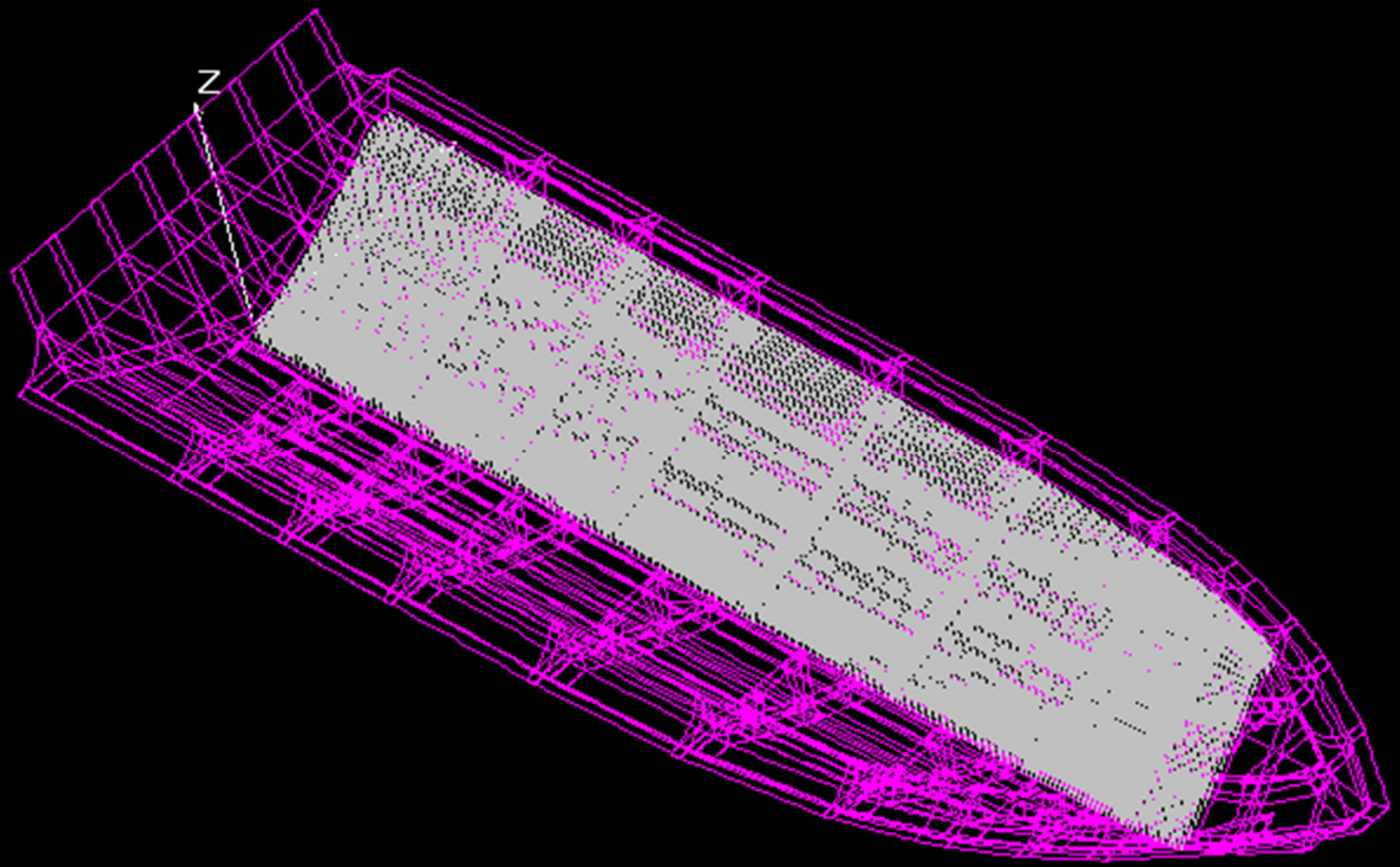




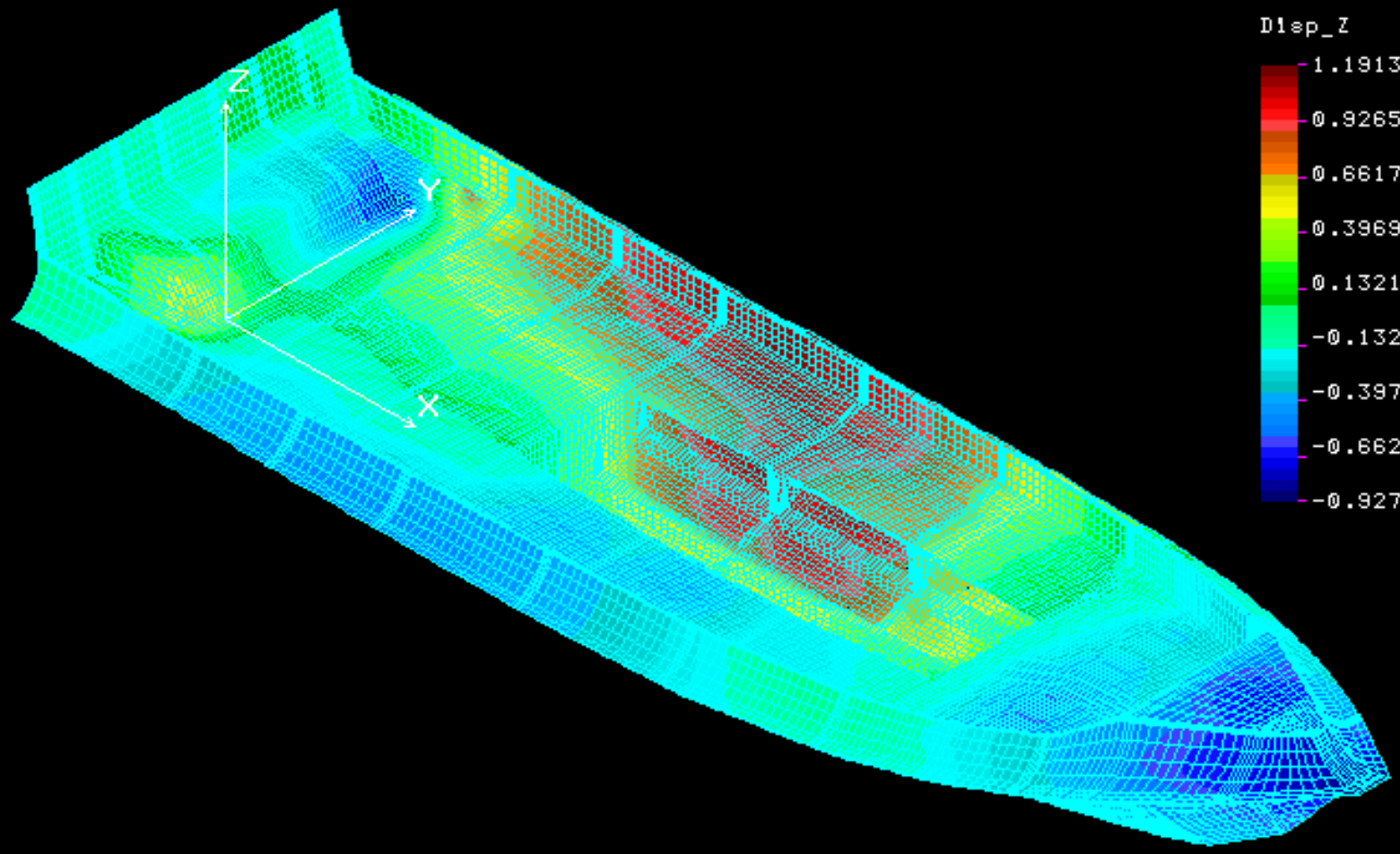
LC6-LAS- Loading

- Pressure load 4.68 psi
- Total load 44,000 lbs
- 11,000 lbs running weight at 4 g's

LC6-LAS- 4.68psi Pressure Load



LC6-LAS- Z Displacement - Deck



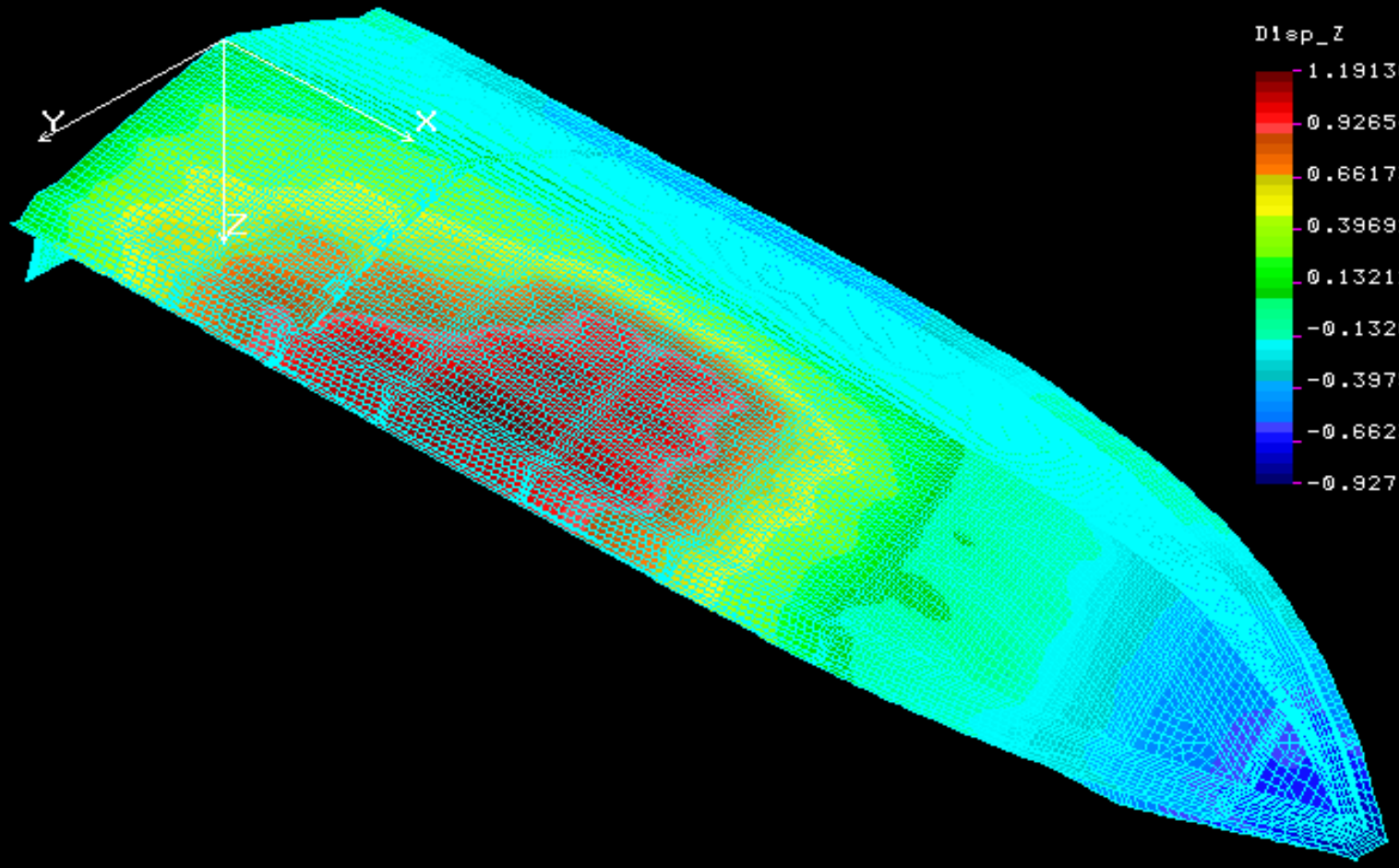
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LC6-LAS- Z Displacement - Hull



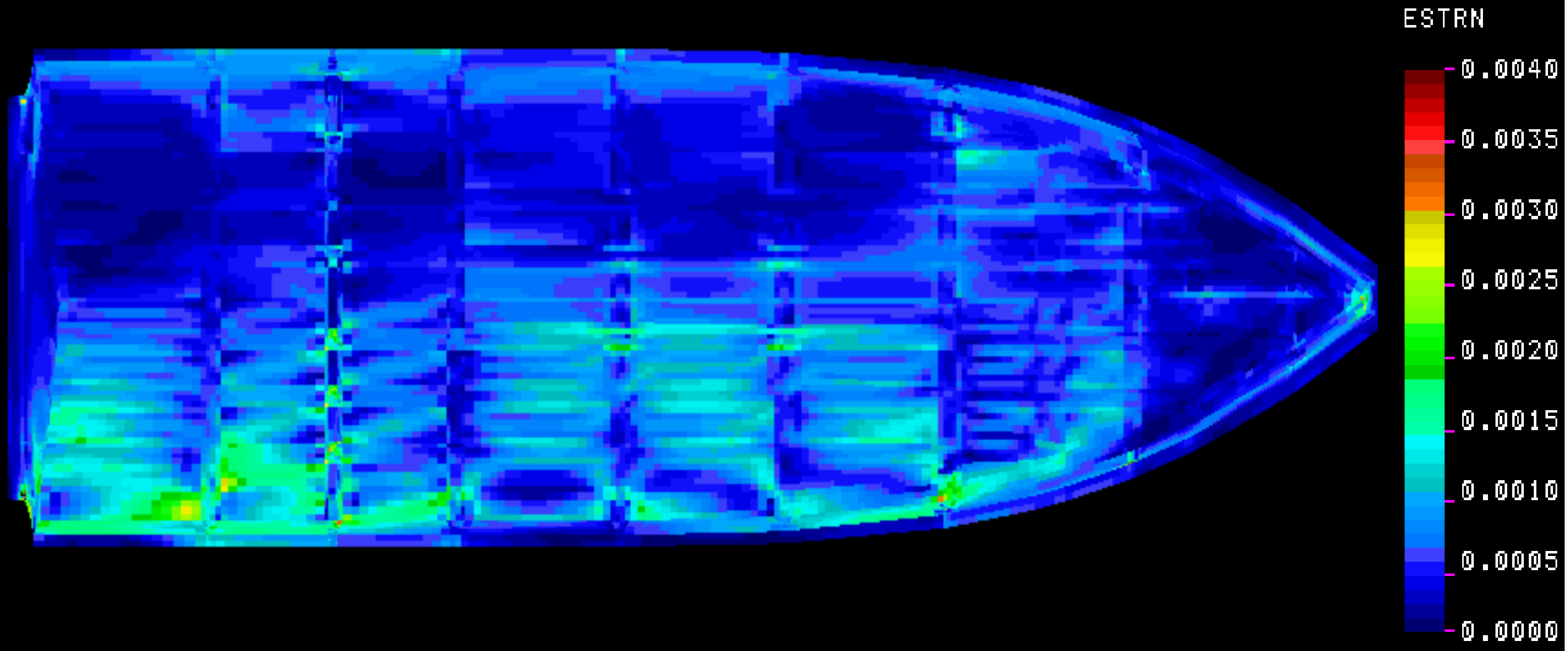
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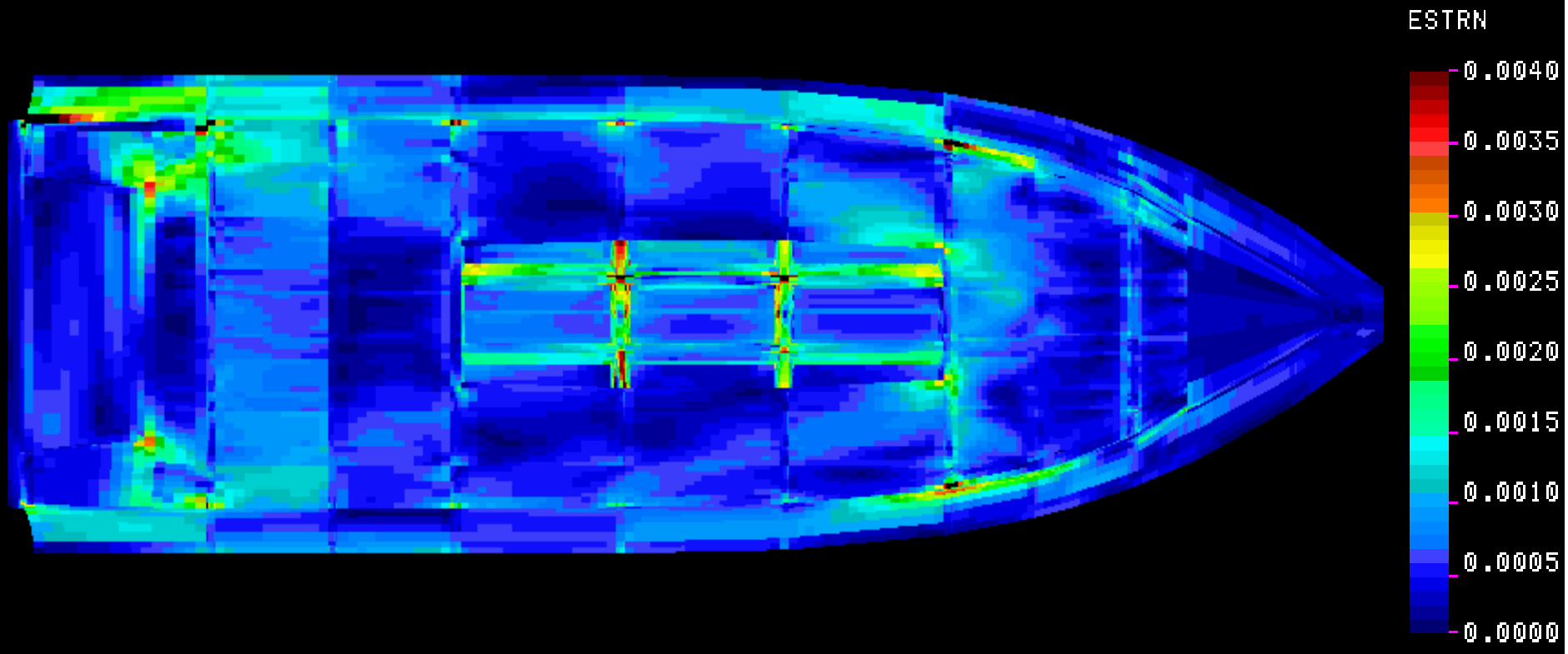
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LC6-LAS- Hull Shell Strain



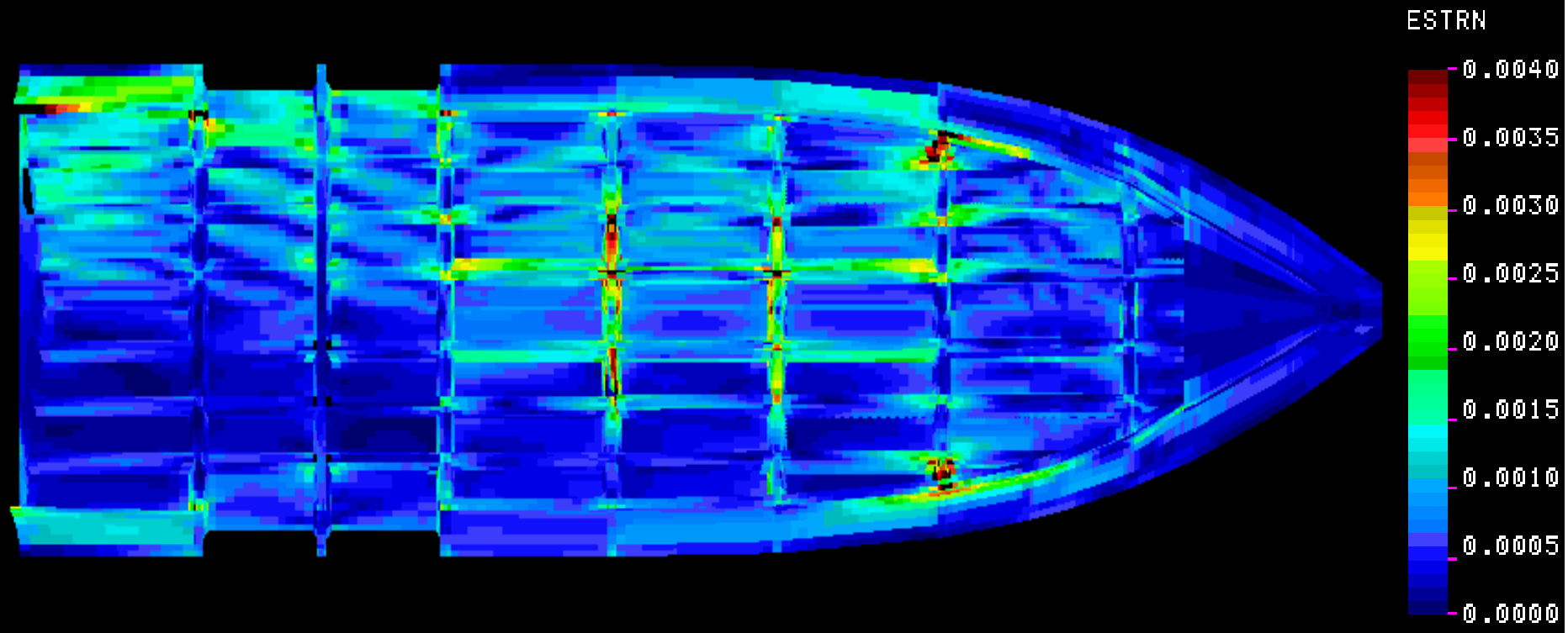
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LC6-LAS- Deck Strain



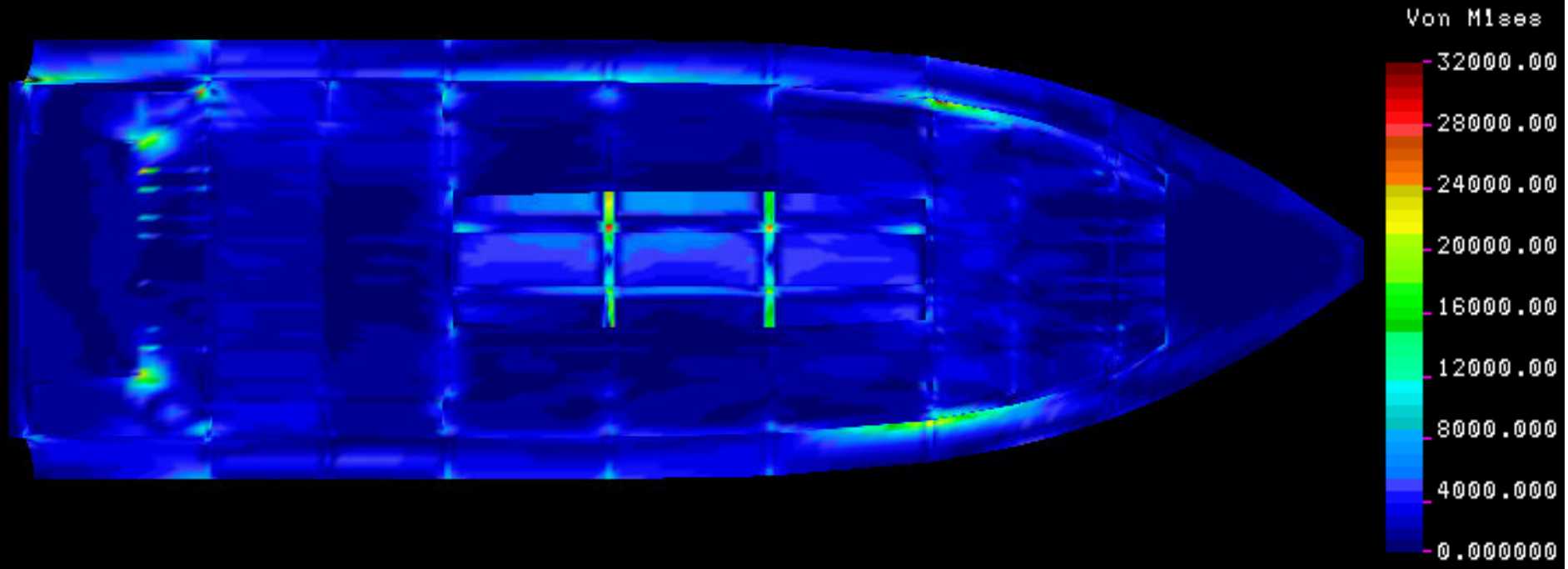
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LC6-LAS- Framing Strain



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LC6-LAS- Deck Longitudinal Stress



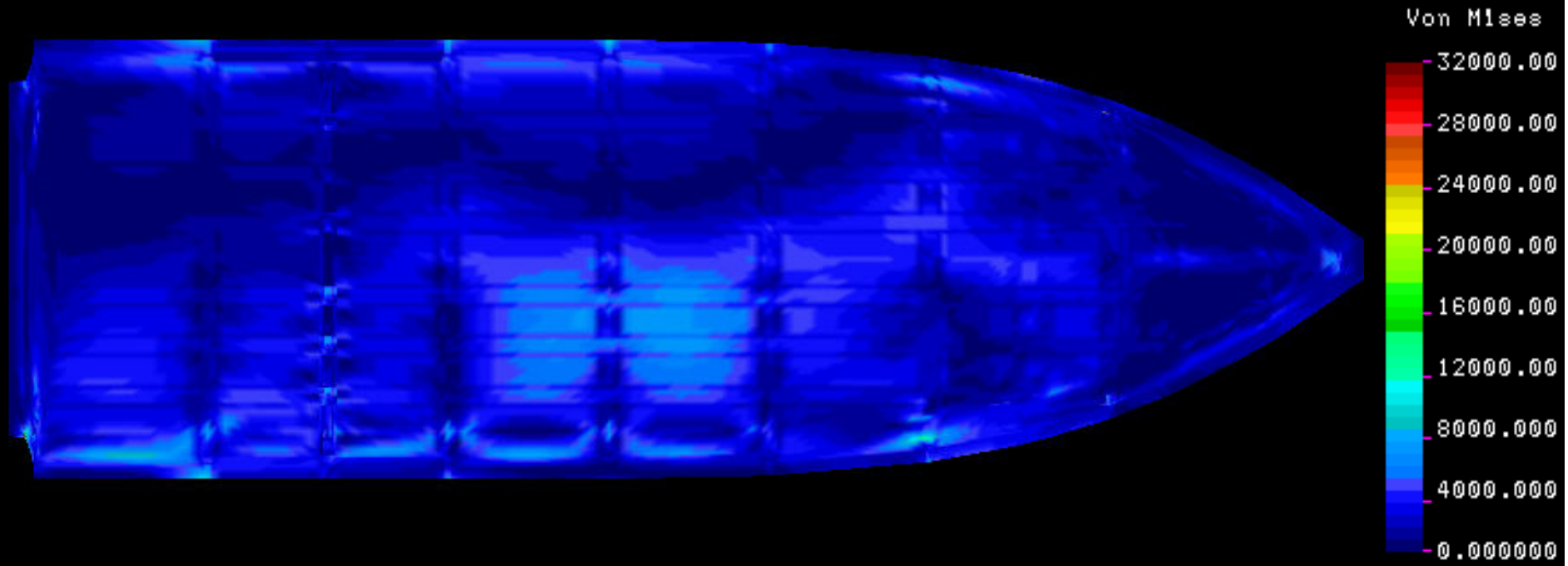
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LC6-LAS- Hull Shell Longitudinal Stress



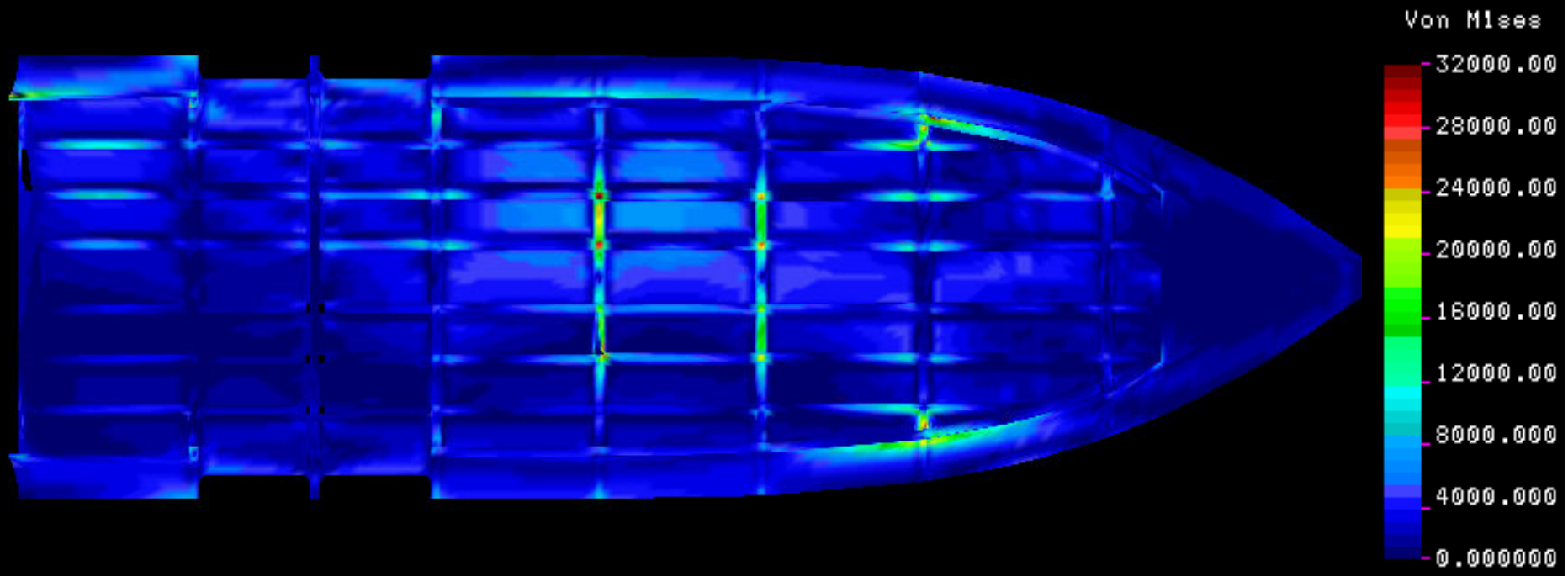
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LC6-LAS- Frame Longitudinal Stress



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LC6-LAS- Deck Transverse Stress



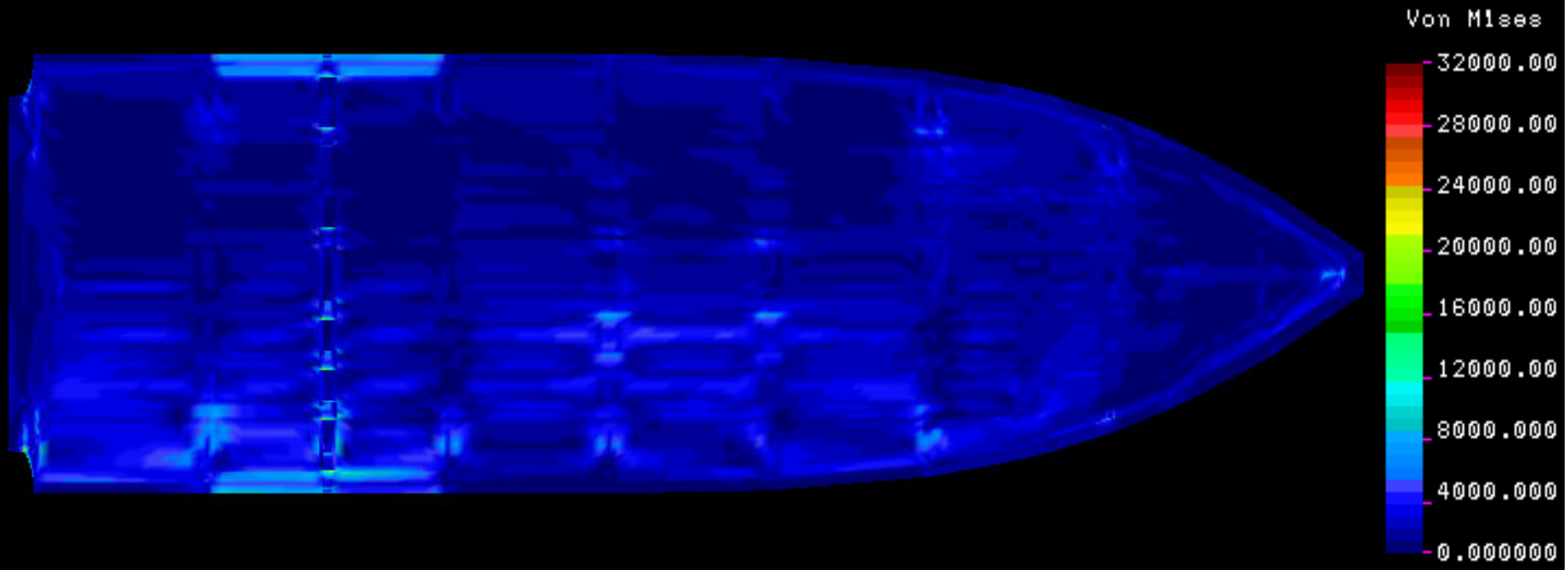
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LC6-LAS- Hull Transverse Stress



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850A- LAS Summary

- Deck range of deflection 1.72 in.
- Hull range of deflection 2.19 in
- Maximum strain 0.025 in/in
- Local panel deflection 0.17 in.
- Maximum longitudinal stress 13,500 psi
- Maximum transverse stress 12,000 psi

850A- FEA Analysis: Calm Water Planning (C.W.P.)

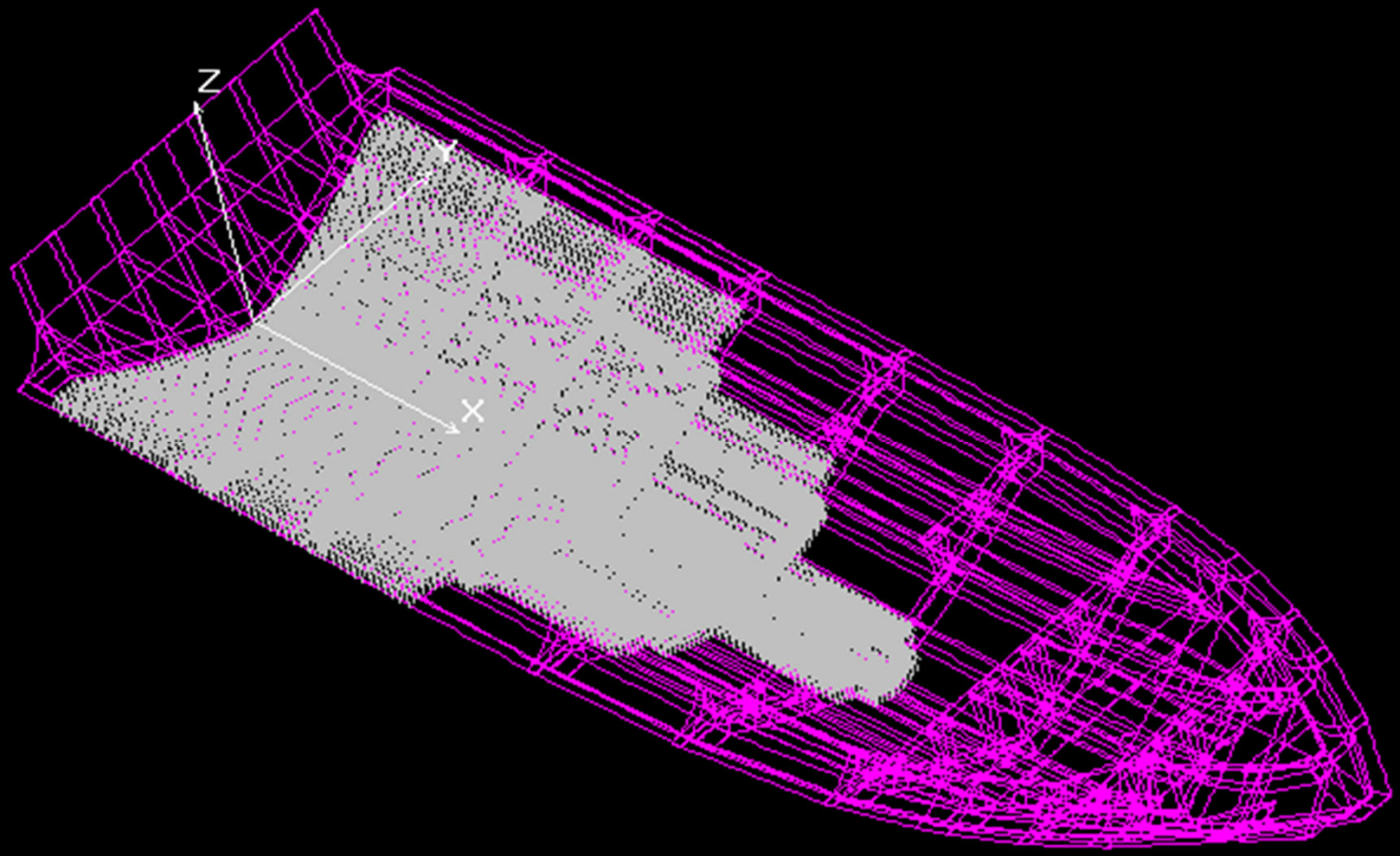


LC7-CWP- Load

- Boat weight 11,000 lbs
- Bottom pressure 1.1 psi (11,000 lbs total)

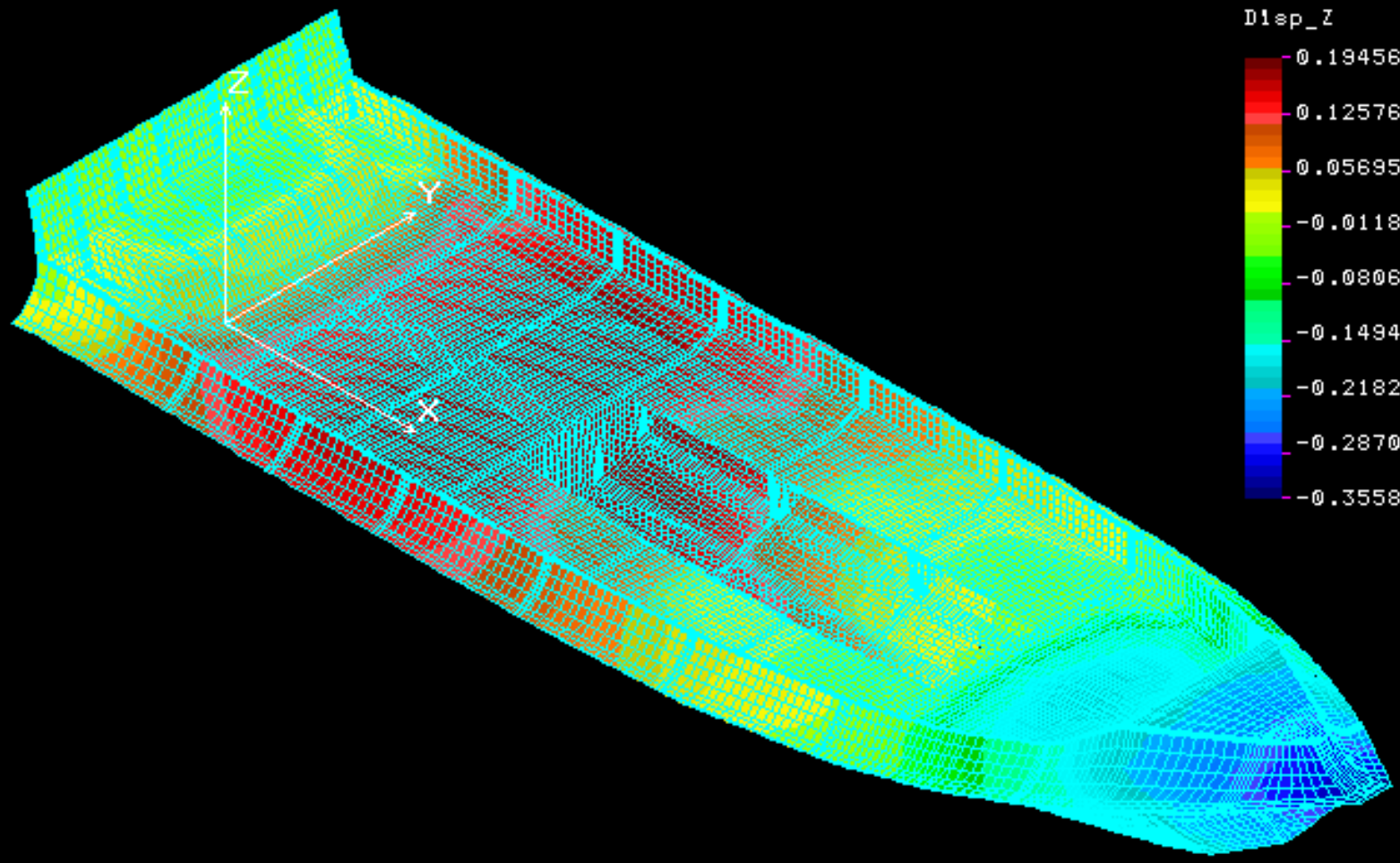
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LC7-CWP- 1.1psi Pressure Load



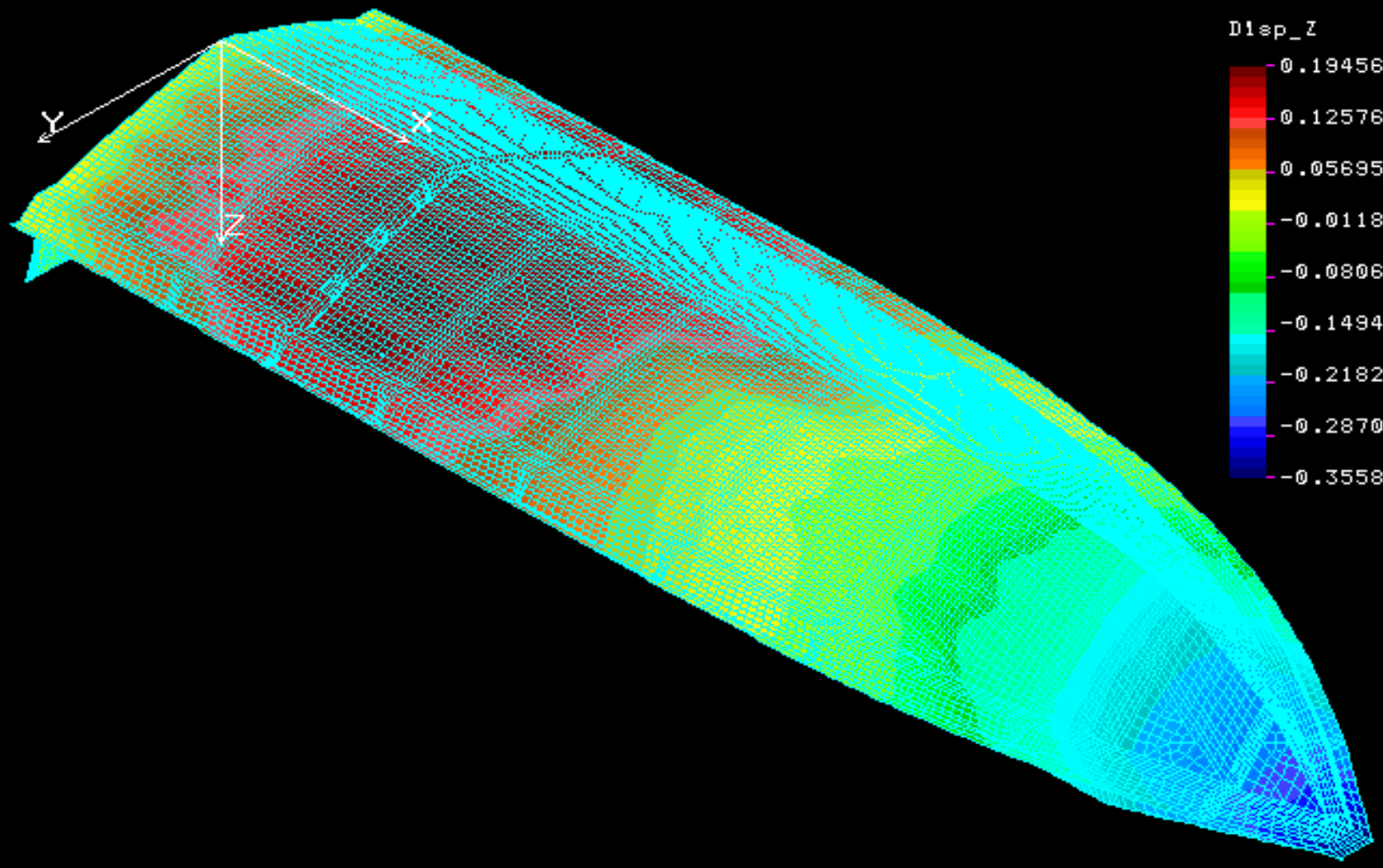
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LC7-CWP- Deck Deflection



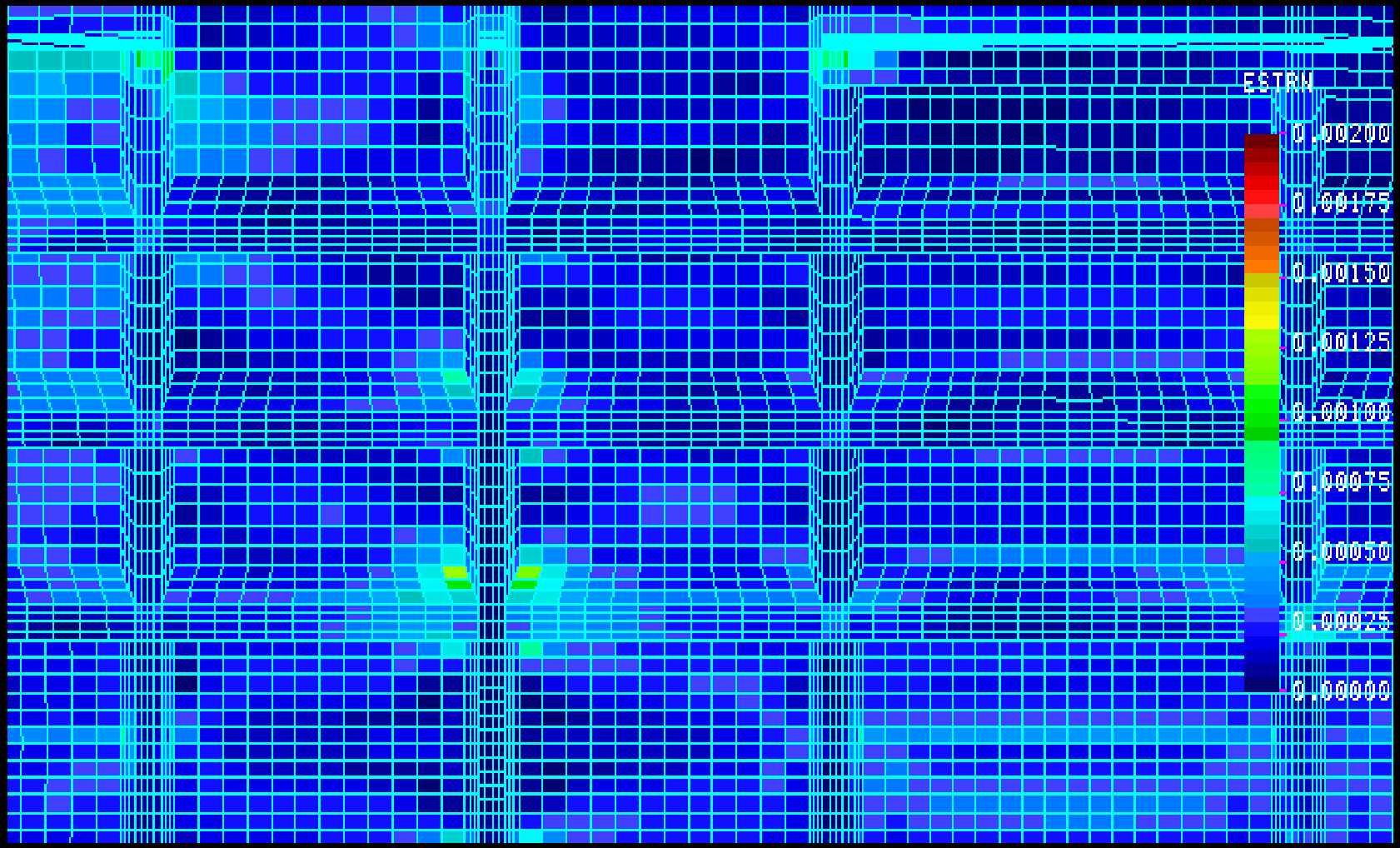
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LC7-CWP- Hull Deflection



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LC7-CWP- Strain



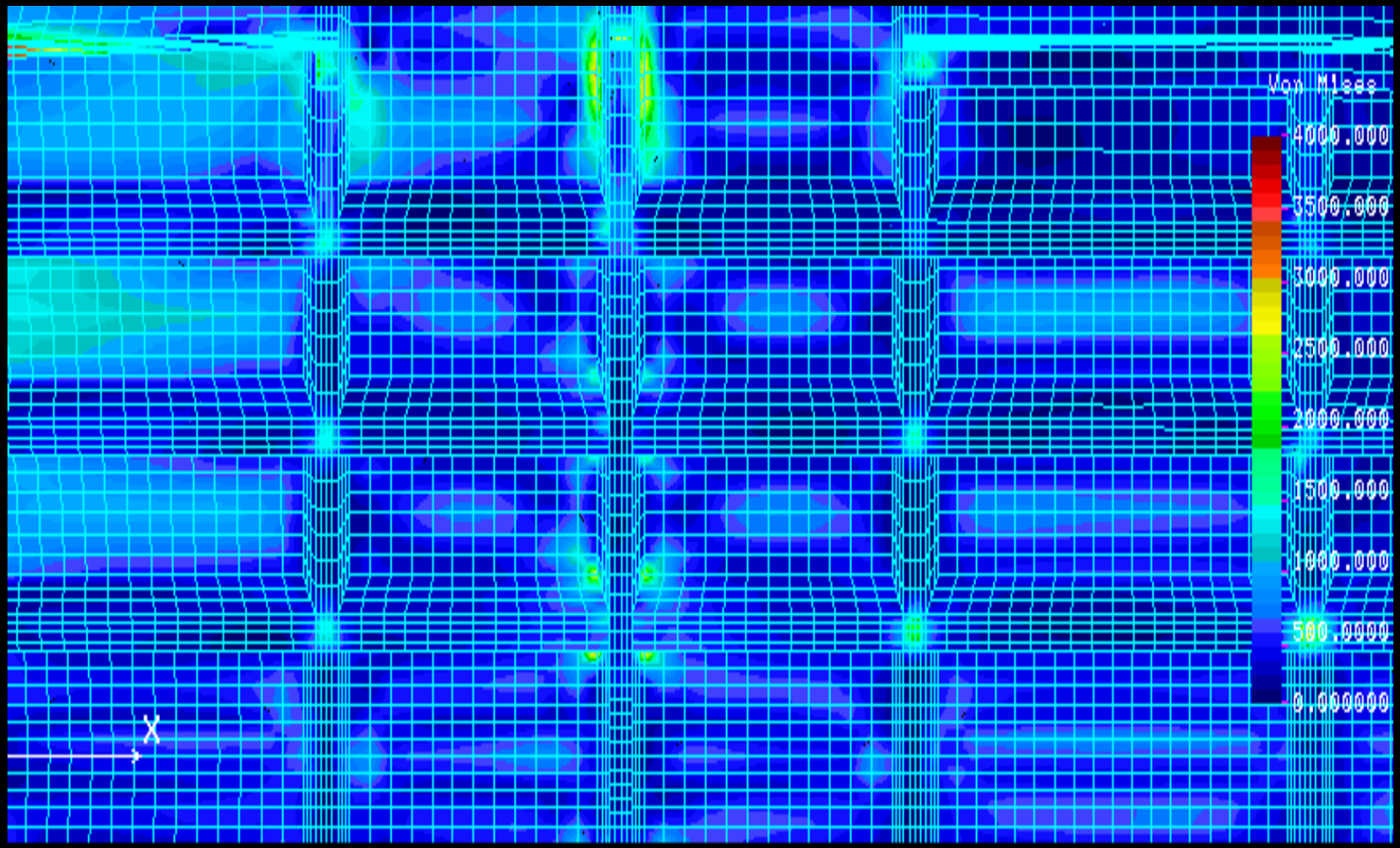
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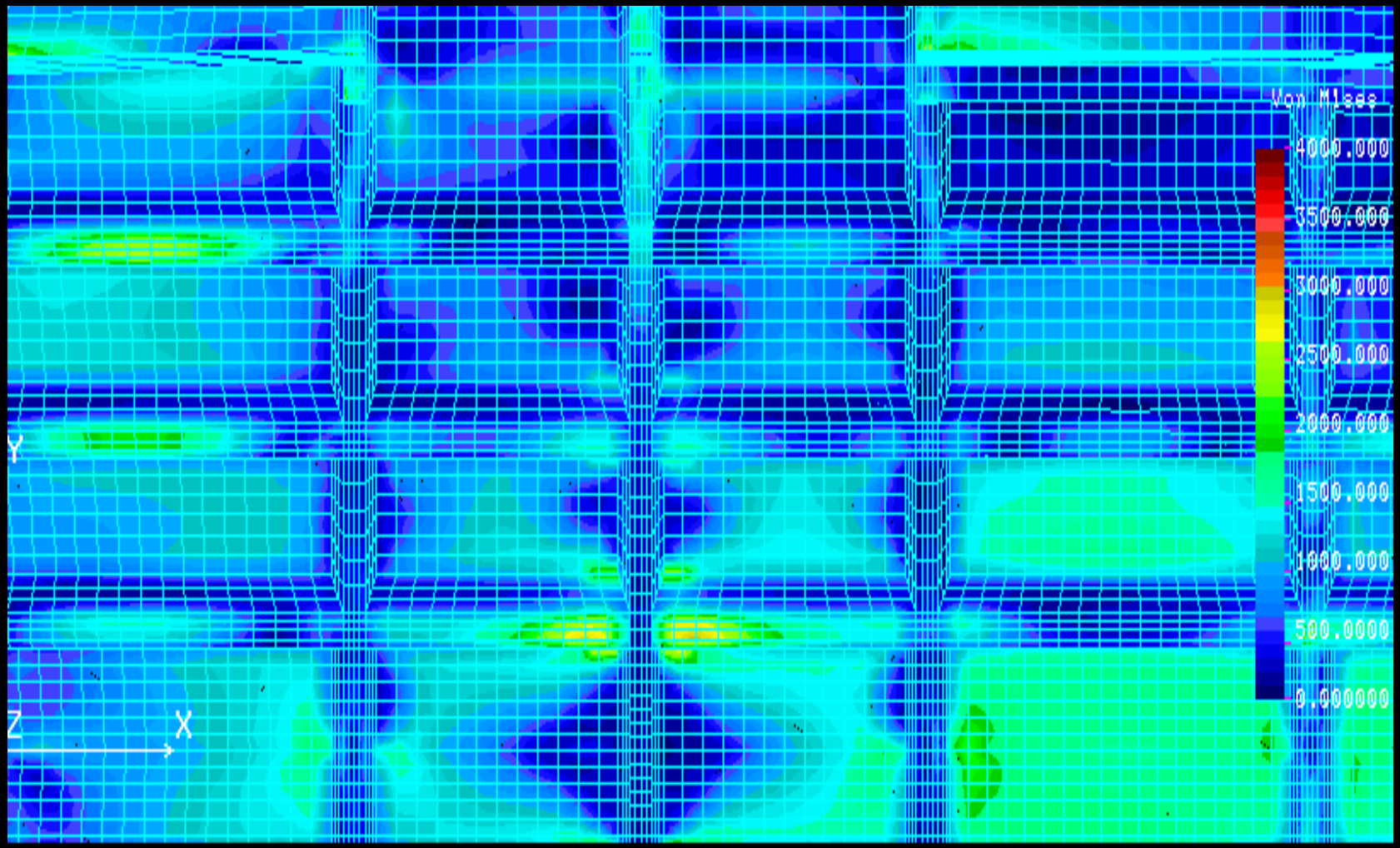
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LC7-CWP- Transverse Stress



LC7-CWP- Longitudinal Stress



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850A- CWP Summary

- Range of deflection 0.52 in.
- Local panel deflection 0.025 in
- Maximum strain 0.0007 in/in
- Maximum longitudinal stress 2000 psi
- Maximum transverse stress 1800 psi

850A- FEA Analysis: Boat Lifting Points (B.L.P.)

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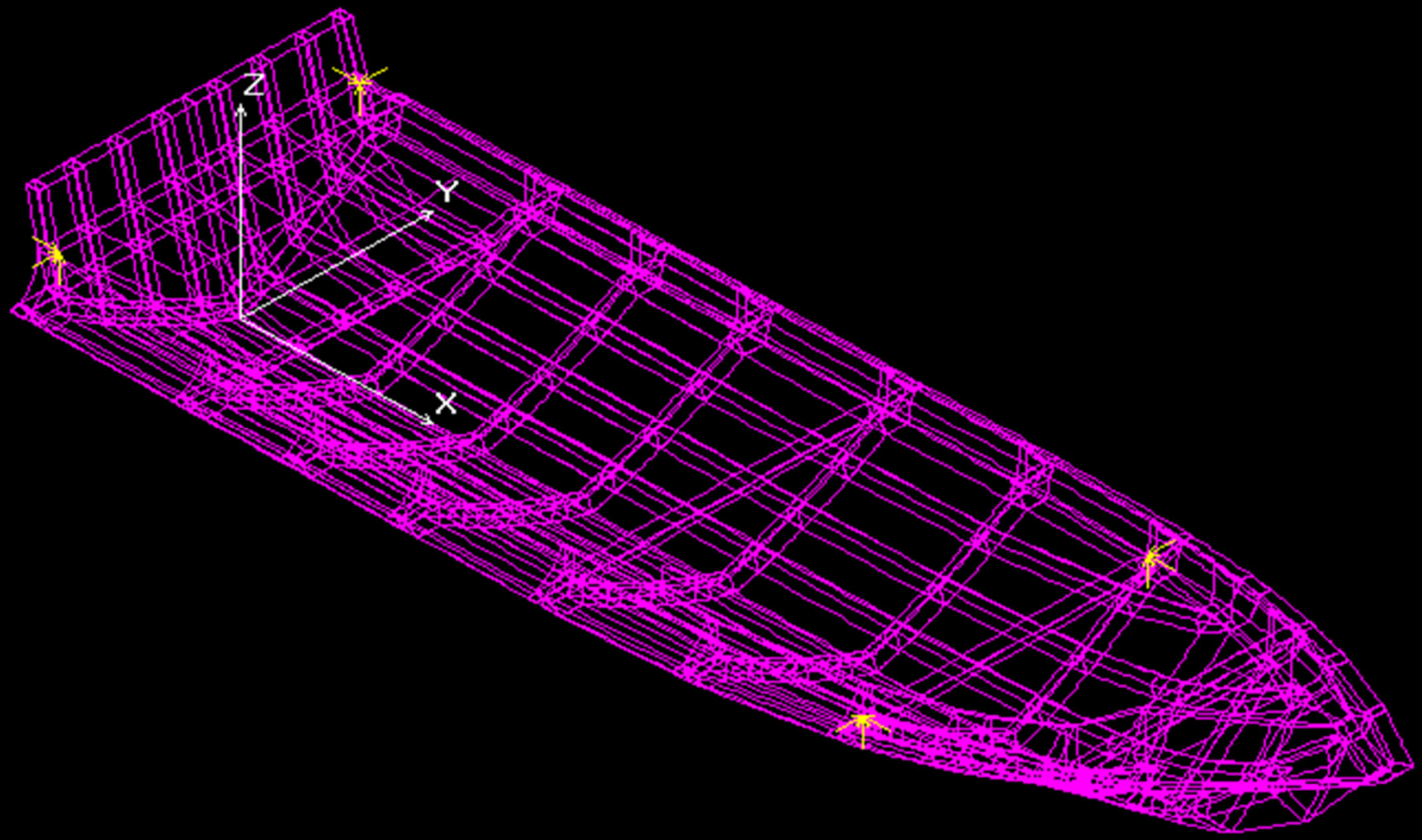
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
  - Redesigned to accommodate tube mounting.
  - Positioned for design LCG

LC8- BLP- Load Data

- Lift weight 7240, SF 6
- 4 point lift
- F_z all four lift points +10860 lbs
- F_x at aft two lift points +3430 lbs
- F_x at fwd two lift points -3430 lbs
- F_y at stbd two lift points +1300 lbs
- F_y at port two lift points -1300 lbs

LC8- BLP- Force Vector at Lift Points



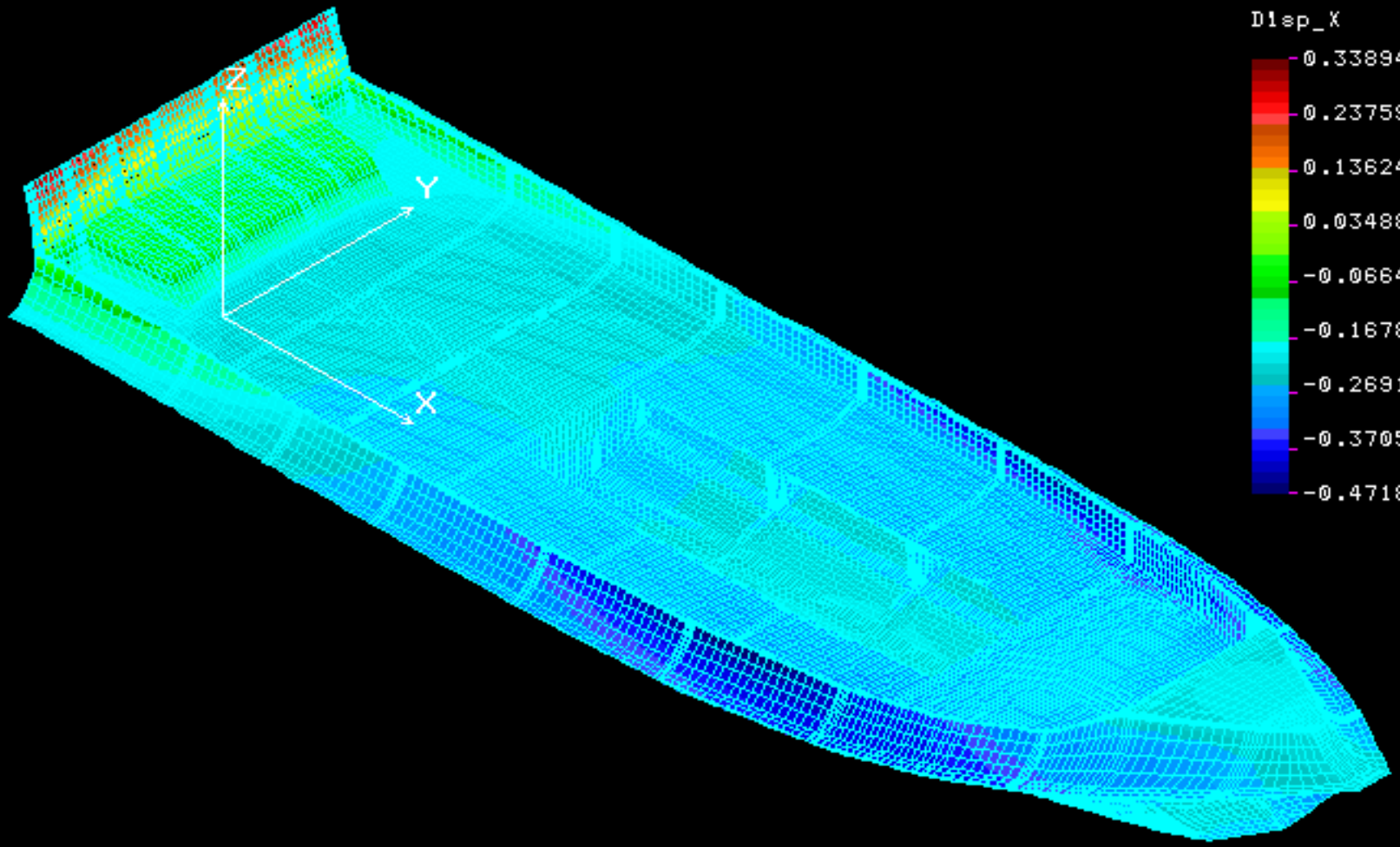
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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints F_r < 1 lb
- Thus constraints do not affect results

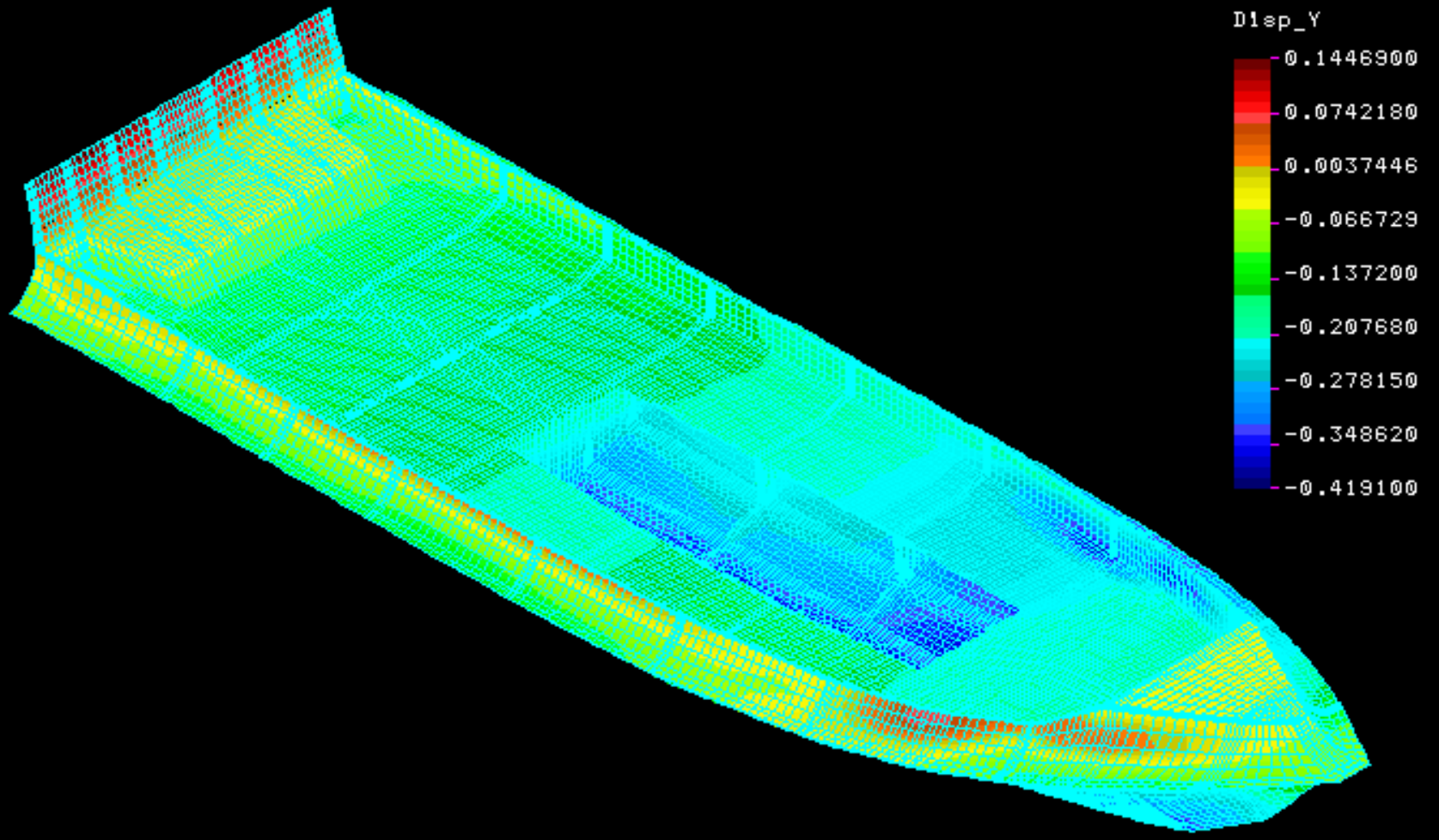
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LC8- BLP- X Displacement



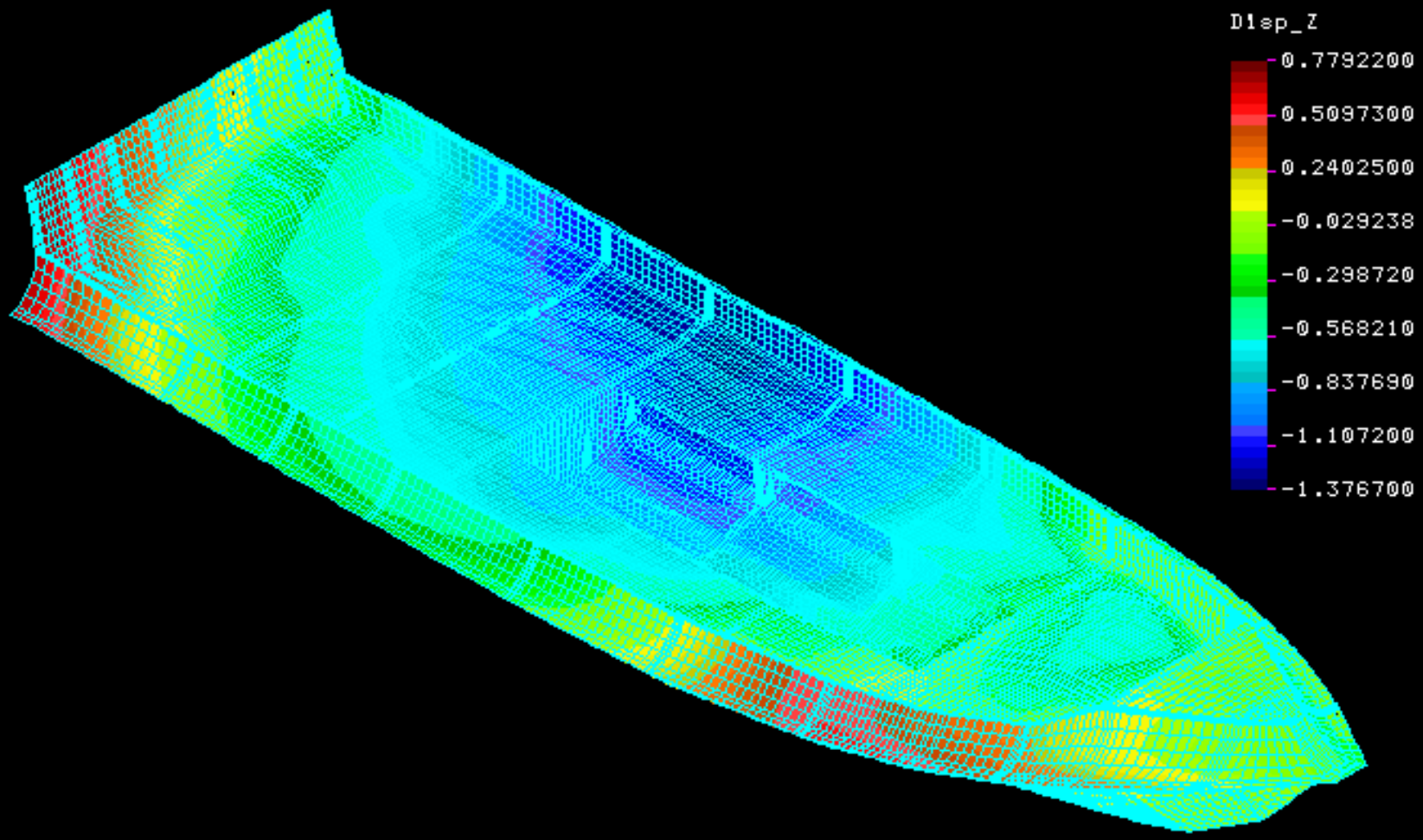
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LC8- BLP- Y Displacement



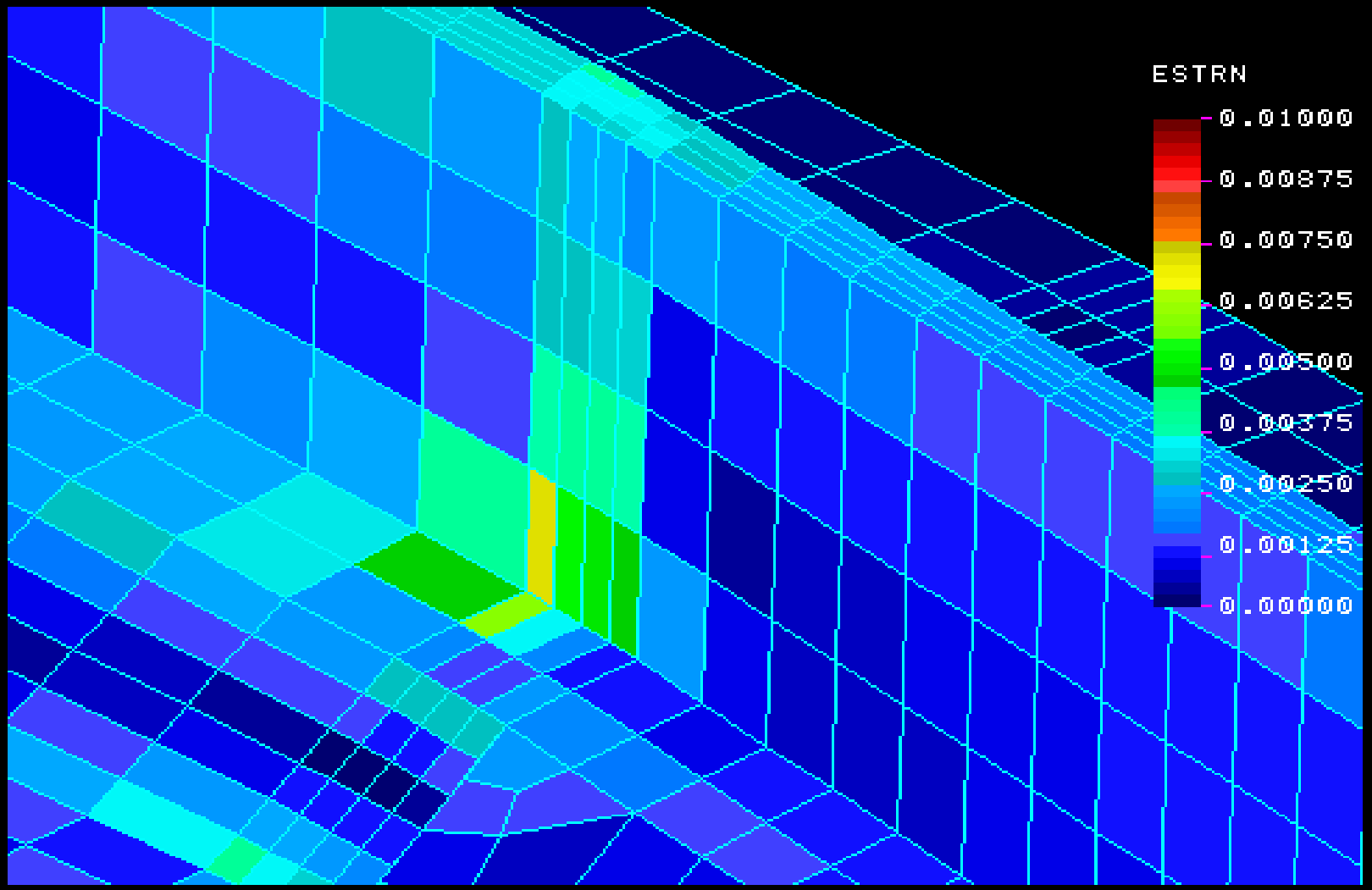
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LC8- BLP- Z Displacement



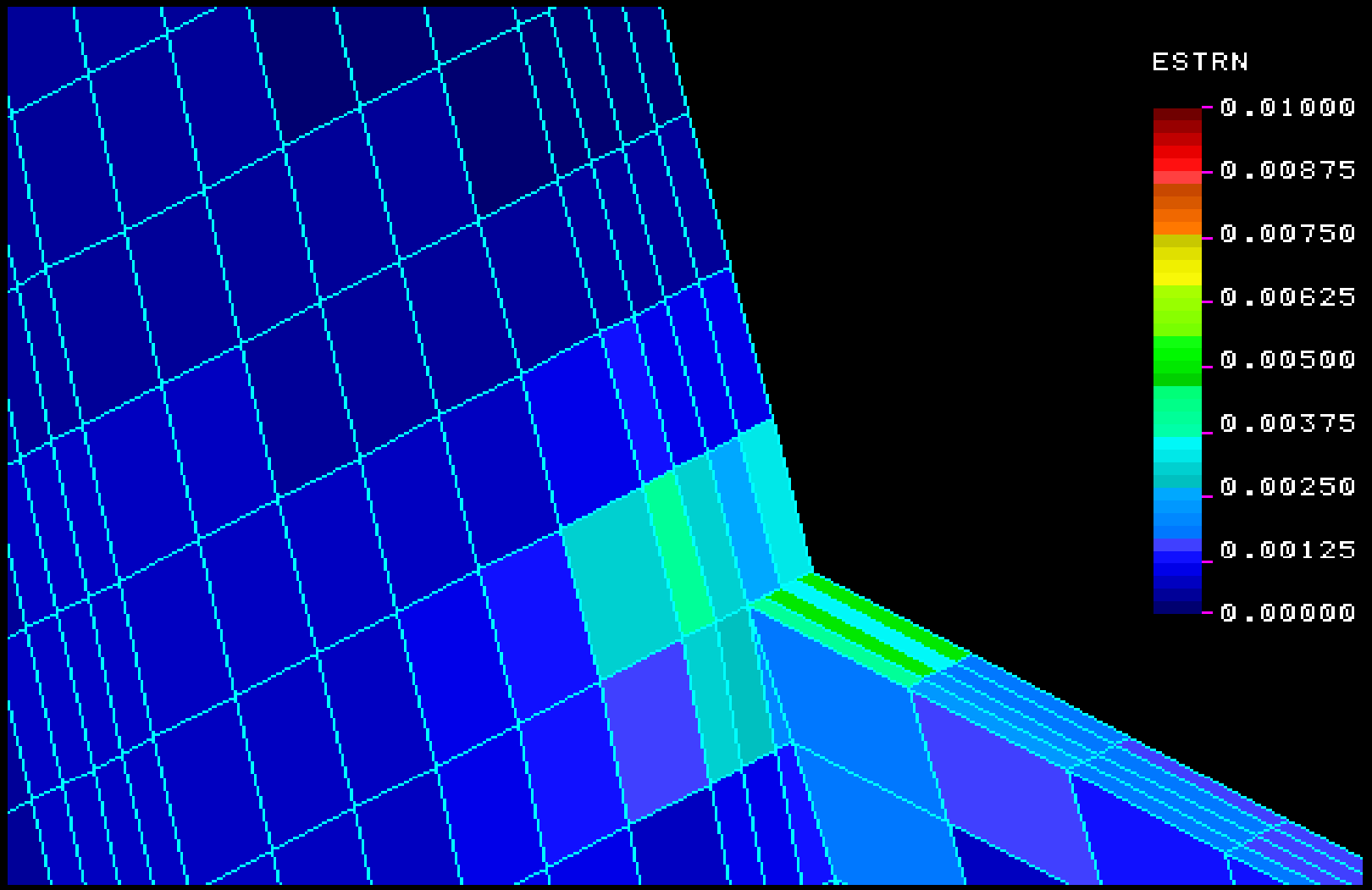
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LC8- BLP- Strain Fwd Lift Point



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LC8- BLP- Strain Aft Lift Point



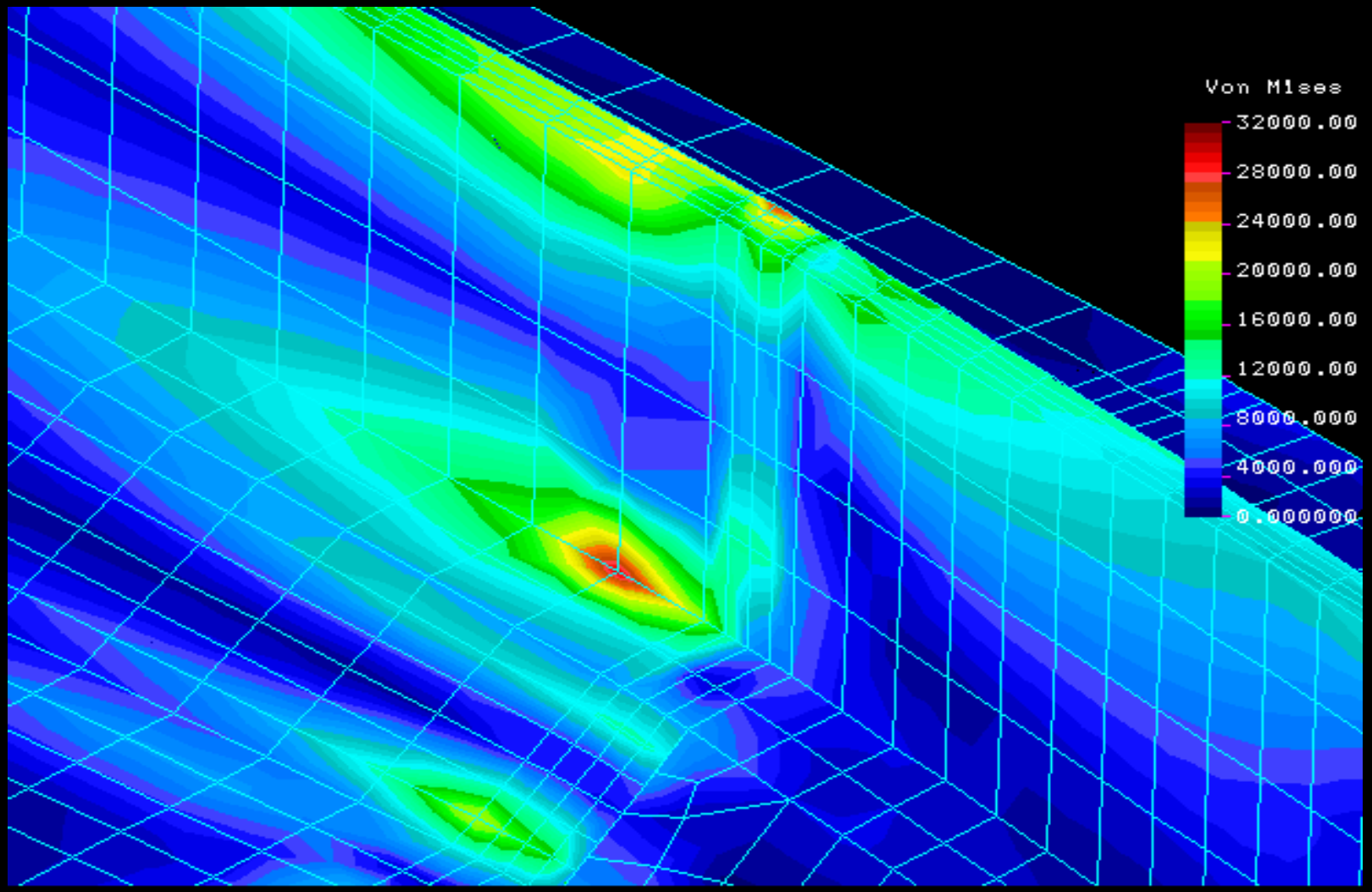
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LC8- BLP- Longitudinal Stress Fwd Lift Point



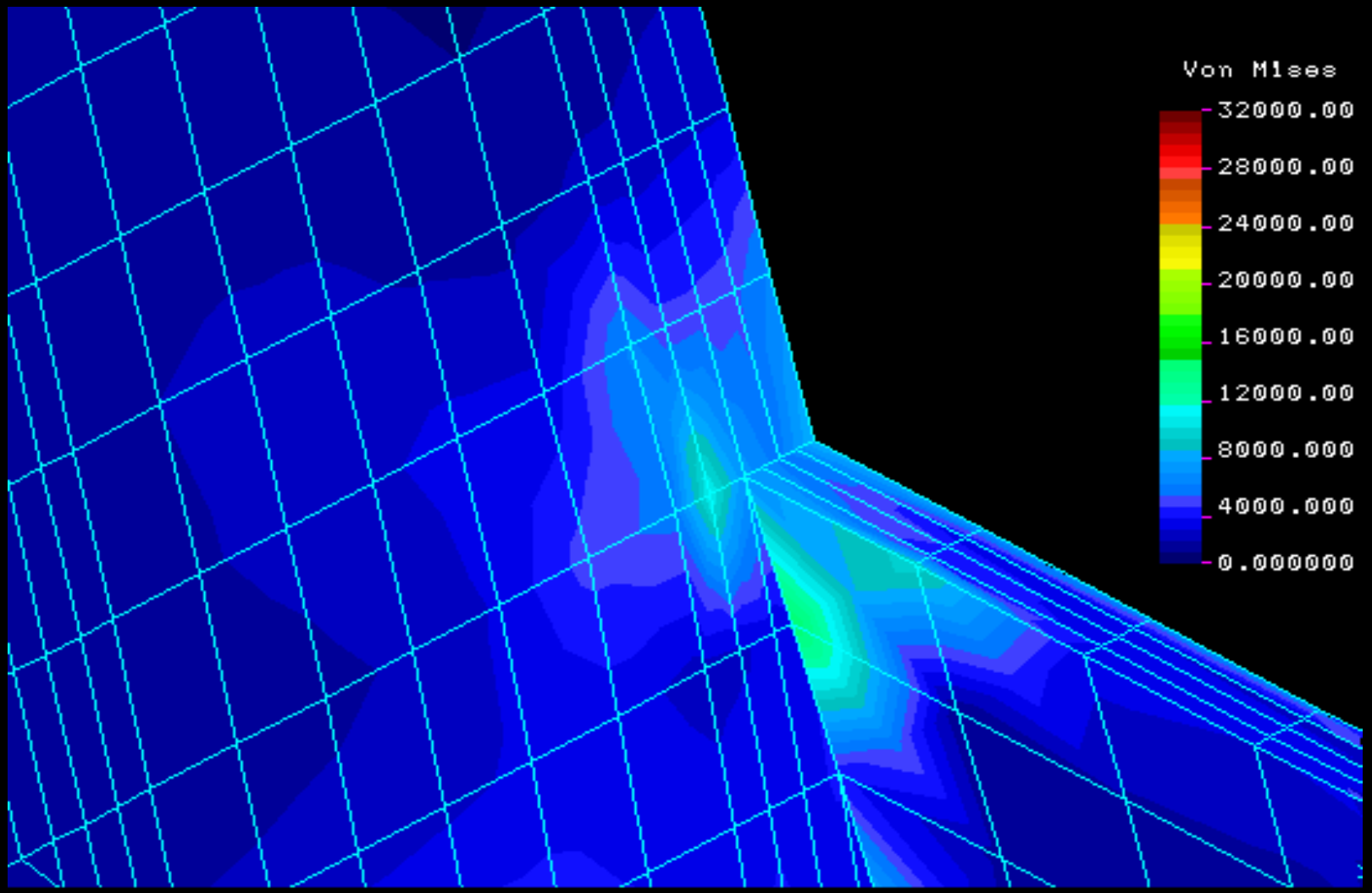
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LC8- BLP- Longitudinal Stress Aft Lift Point



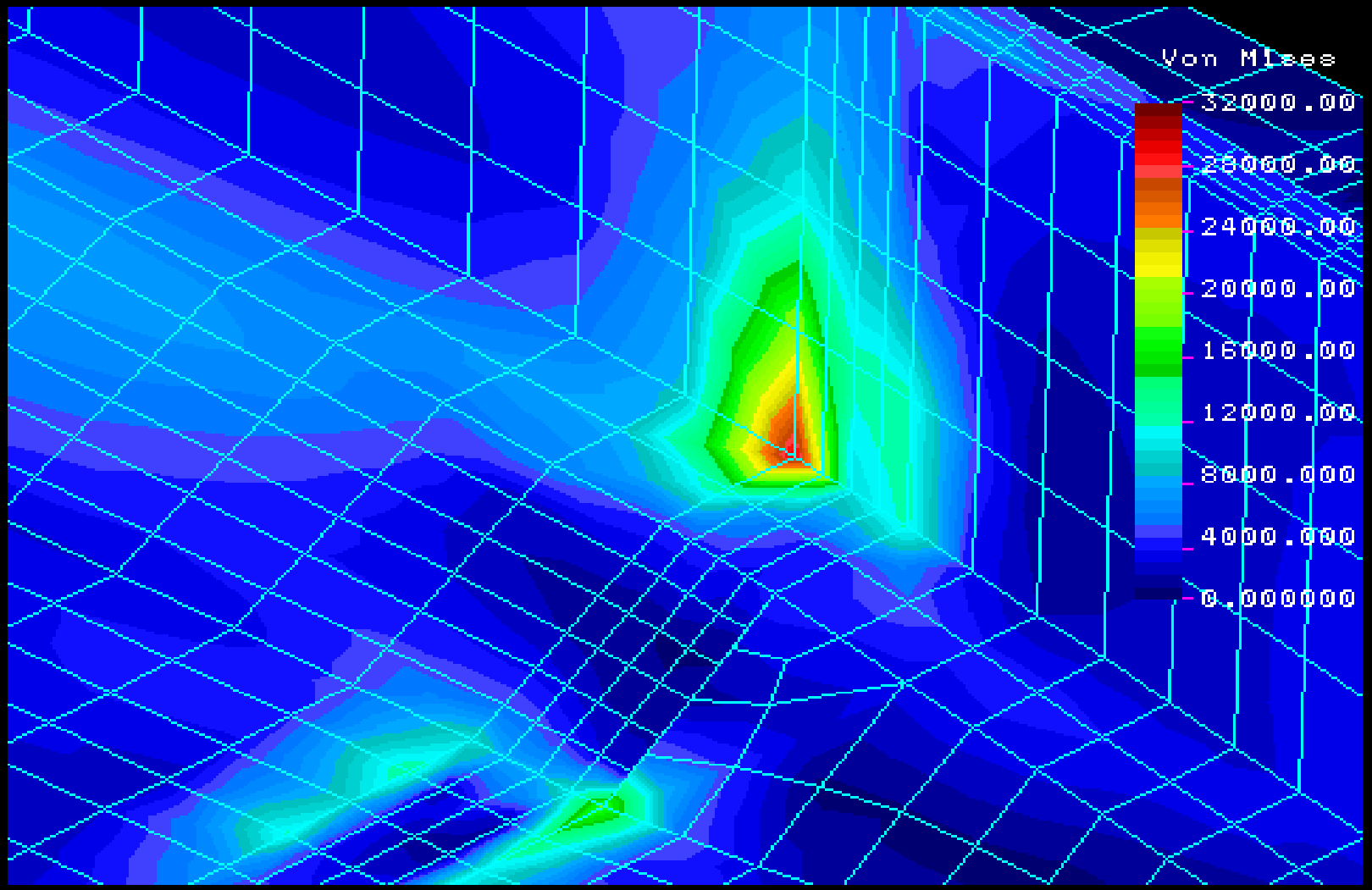
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LC8- BLP- Transverse Stress Fwd Lift Point



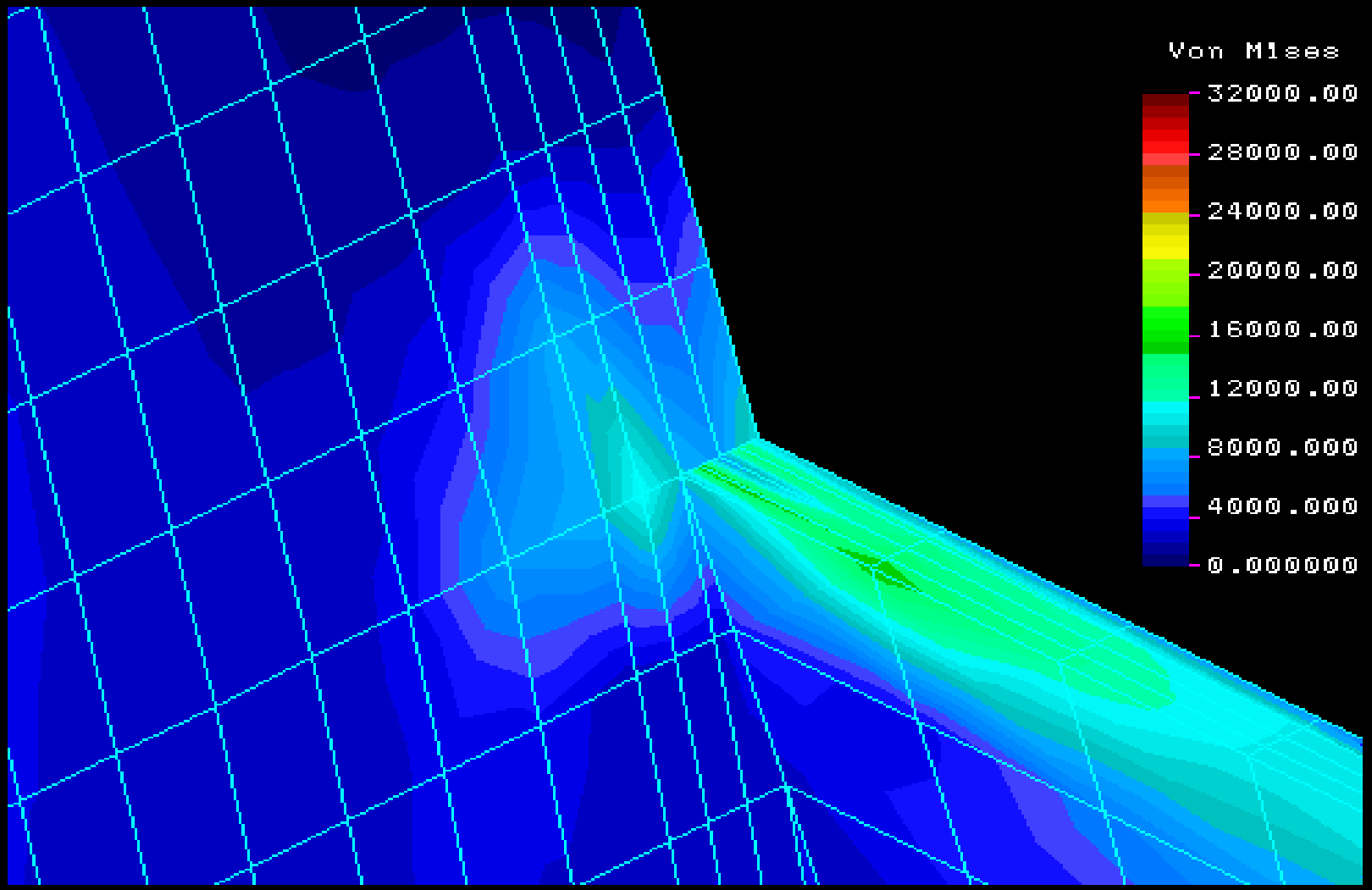
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LC8- BLP- Transverse Stress Aft Lift Point



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LC8- BLP- Lift Analysis Summary

- Model shows structure is adequate for this load case
- FOS: 6
- Range of deflection 1.7 in.
- Maximum strain at lift points 0.0067 in/in
- Maximum longitudinal stress 20,000 psi
- Maximum transverse stress 24,500 psi

850A- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

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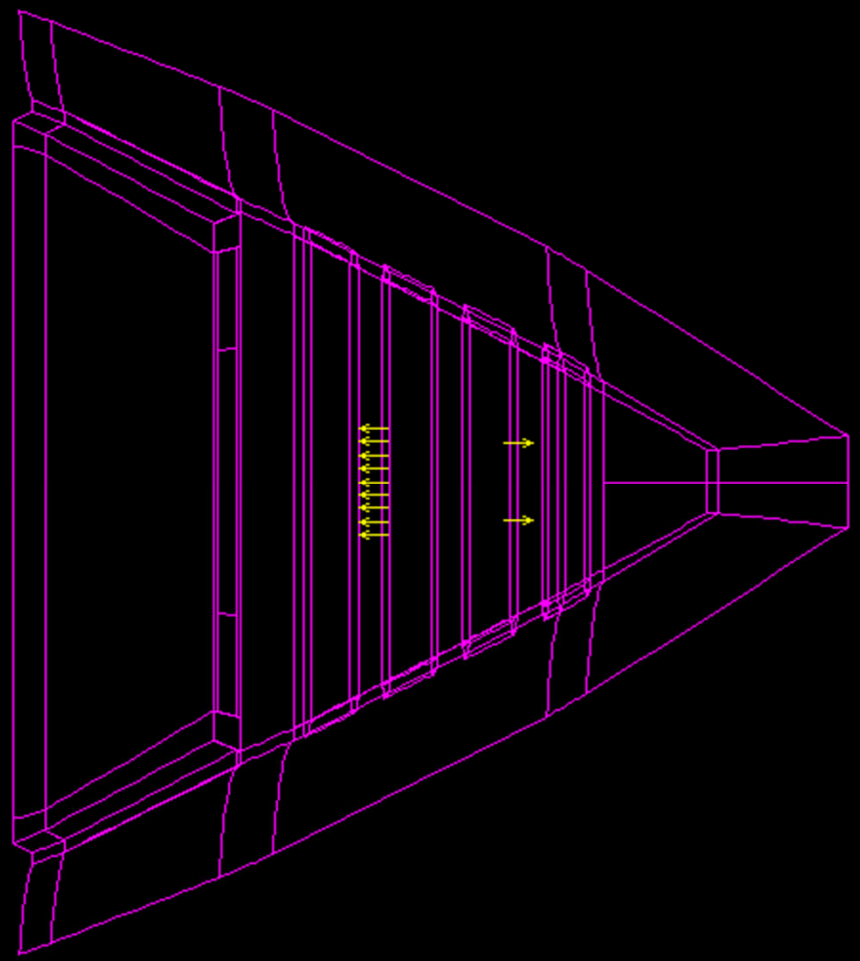
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Gun Mount Framing Notes

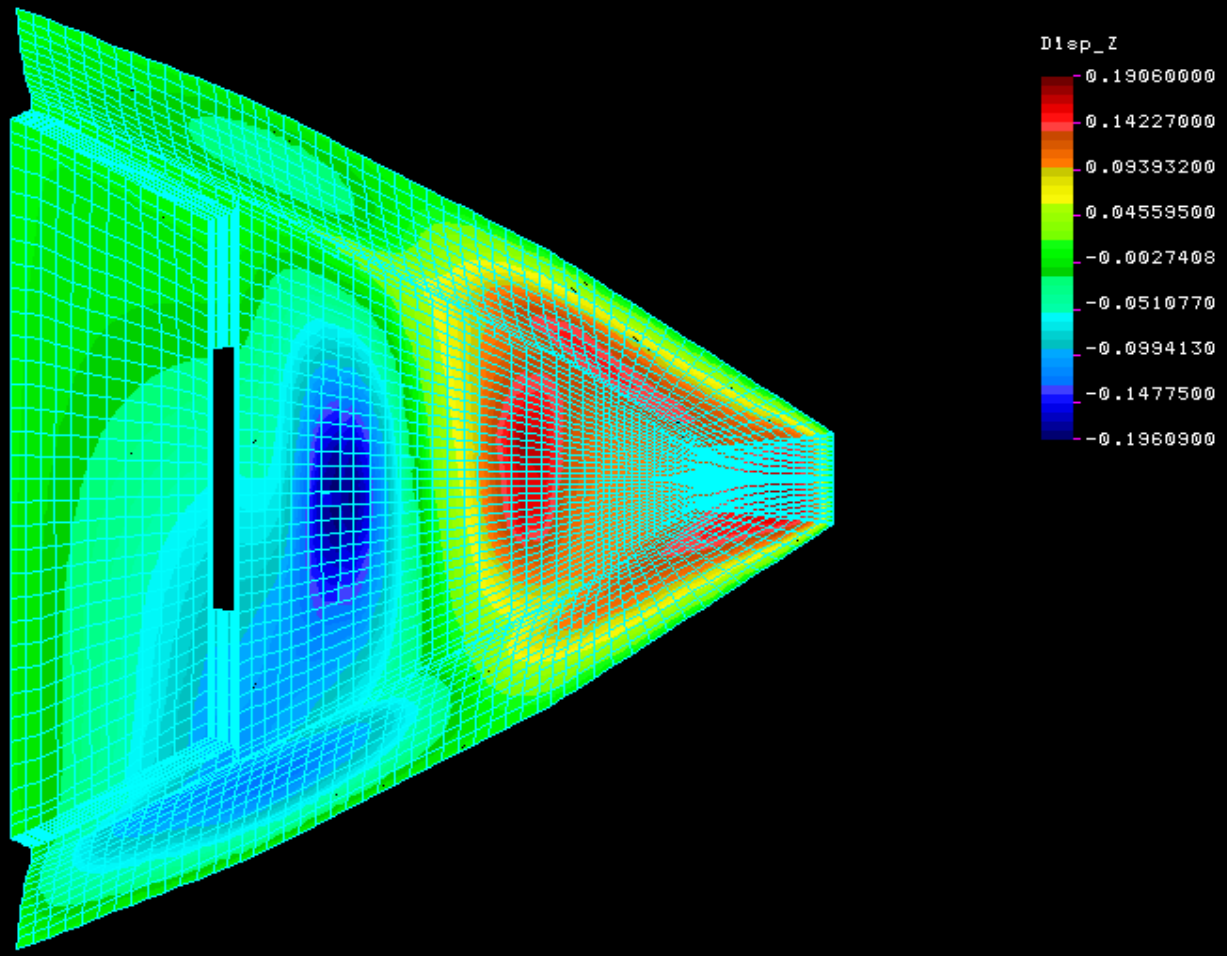
- Four transverse frames, TR3030X, are placed on five inch centers
- Skin laminate is four layers of 3610
- Frame laminate:
  - 24 oz (+/-45) on PRISMA Beam
  - 4 layers 1810 warp uni
  - 2408 (+/-45) cover fabric

LC9- GML- Long. Loading



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LC9- GML- Z Displacement



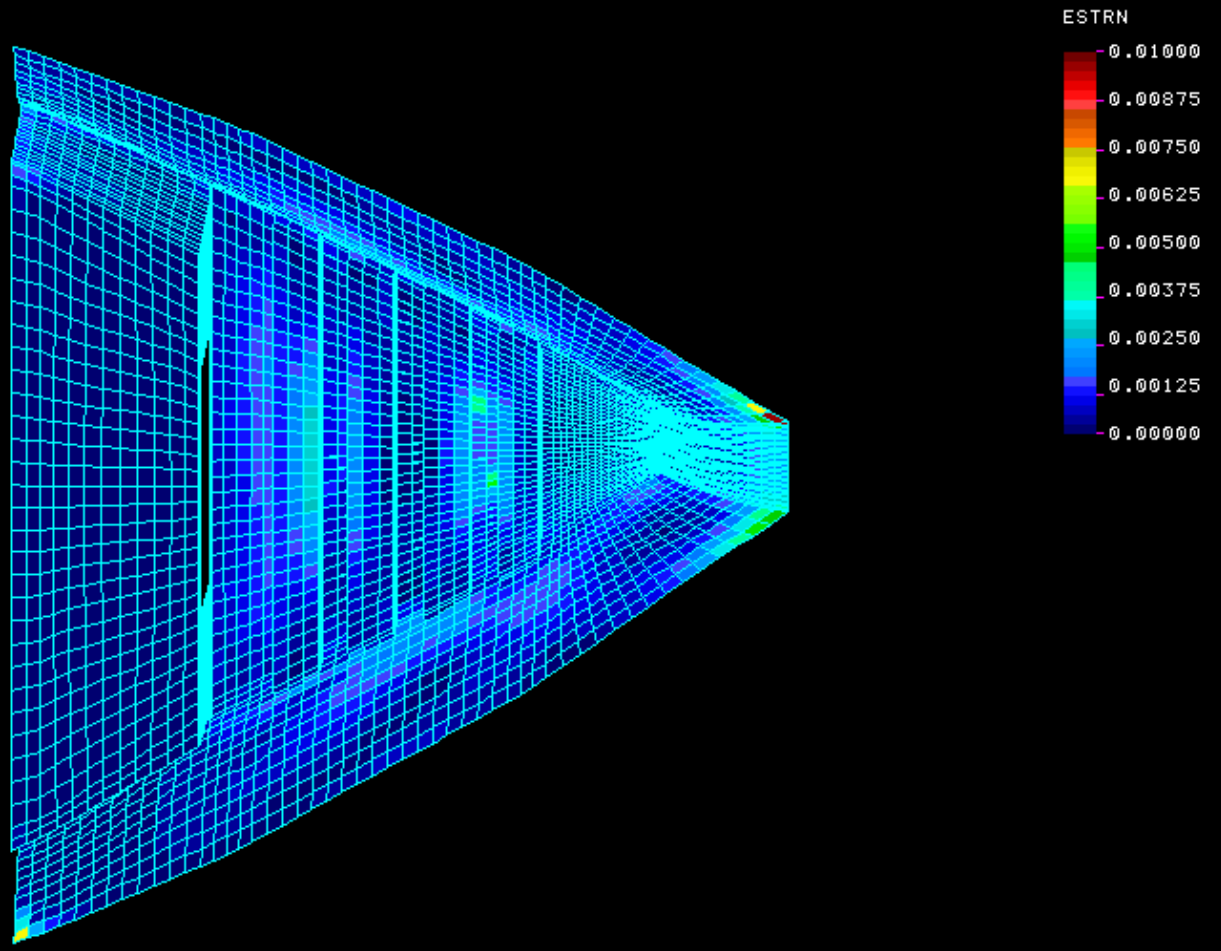
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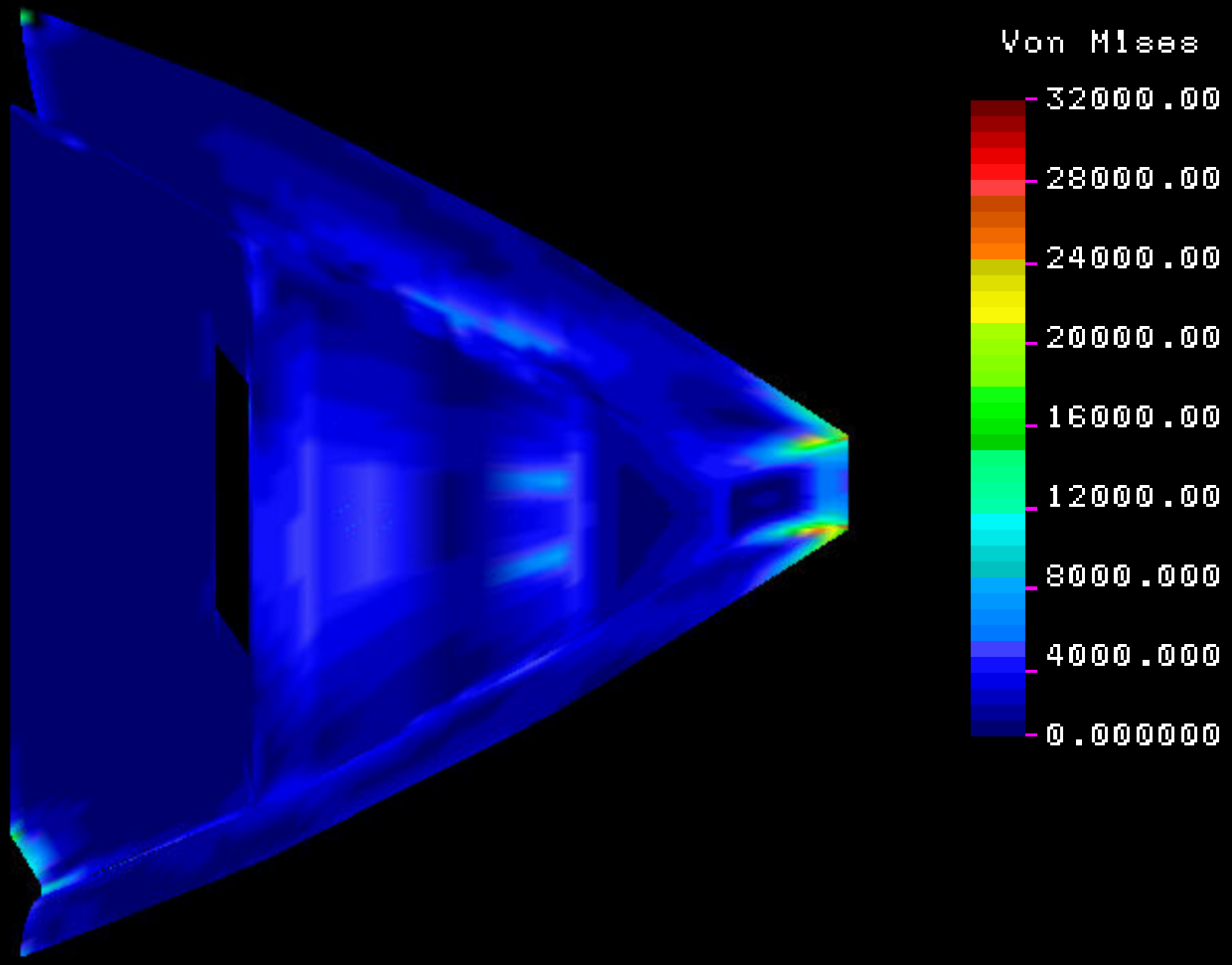
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LC9- GML- Strain (Bottom View)



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LC9- GML- Stress in Long. Ply (Top)



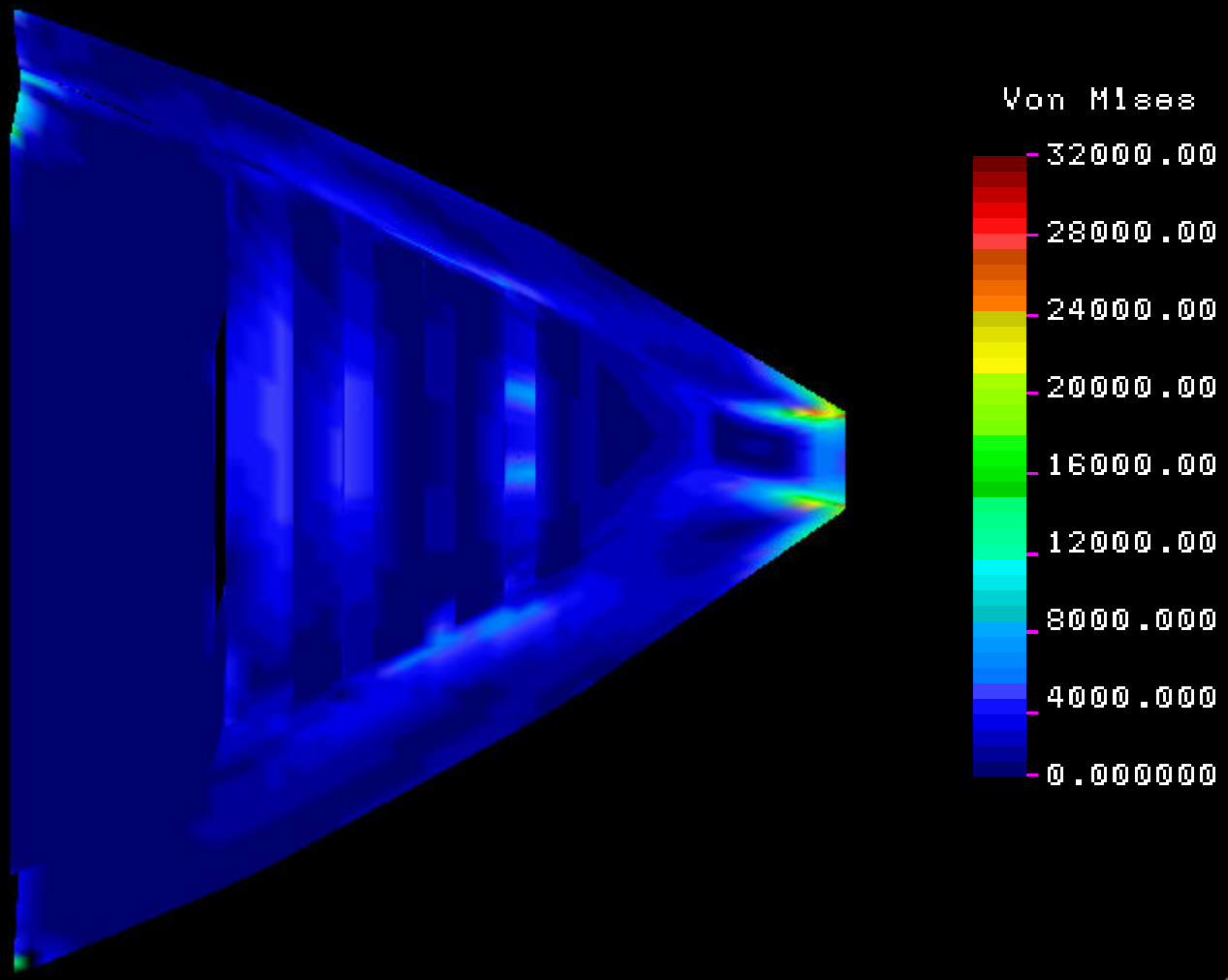
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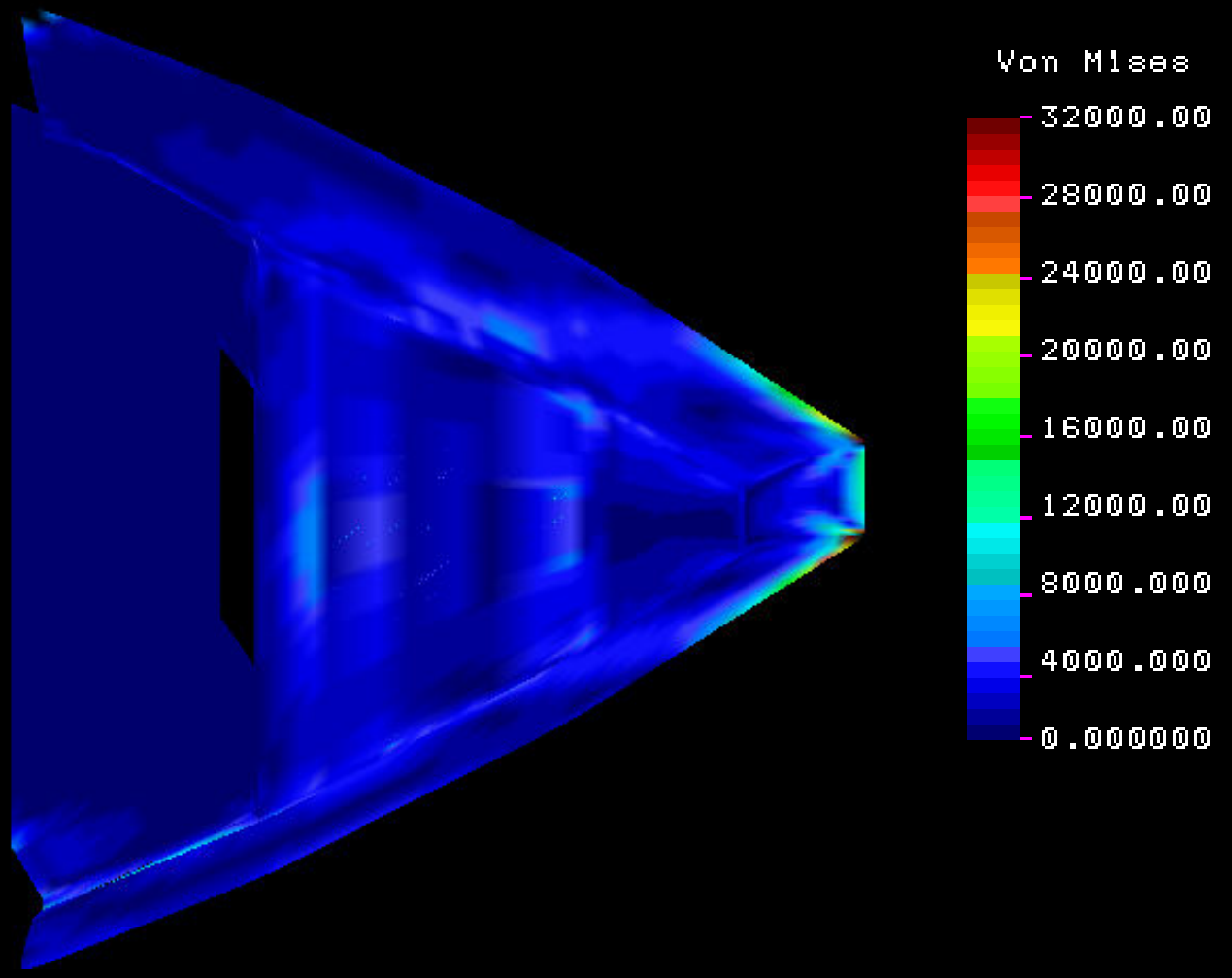
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LC9- GML- Stress in Long. Ply (Bottom)



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LC9- GML- Stress in Tran. Ply (Top)



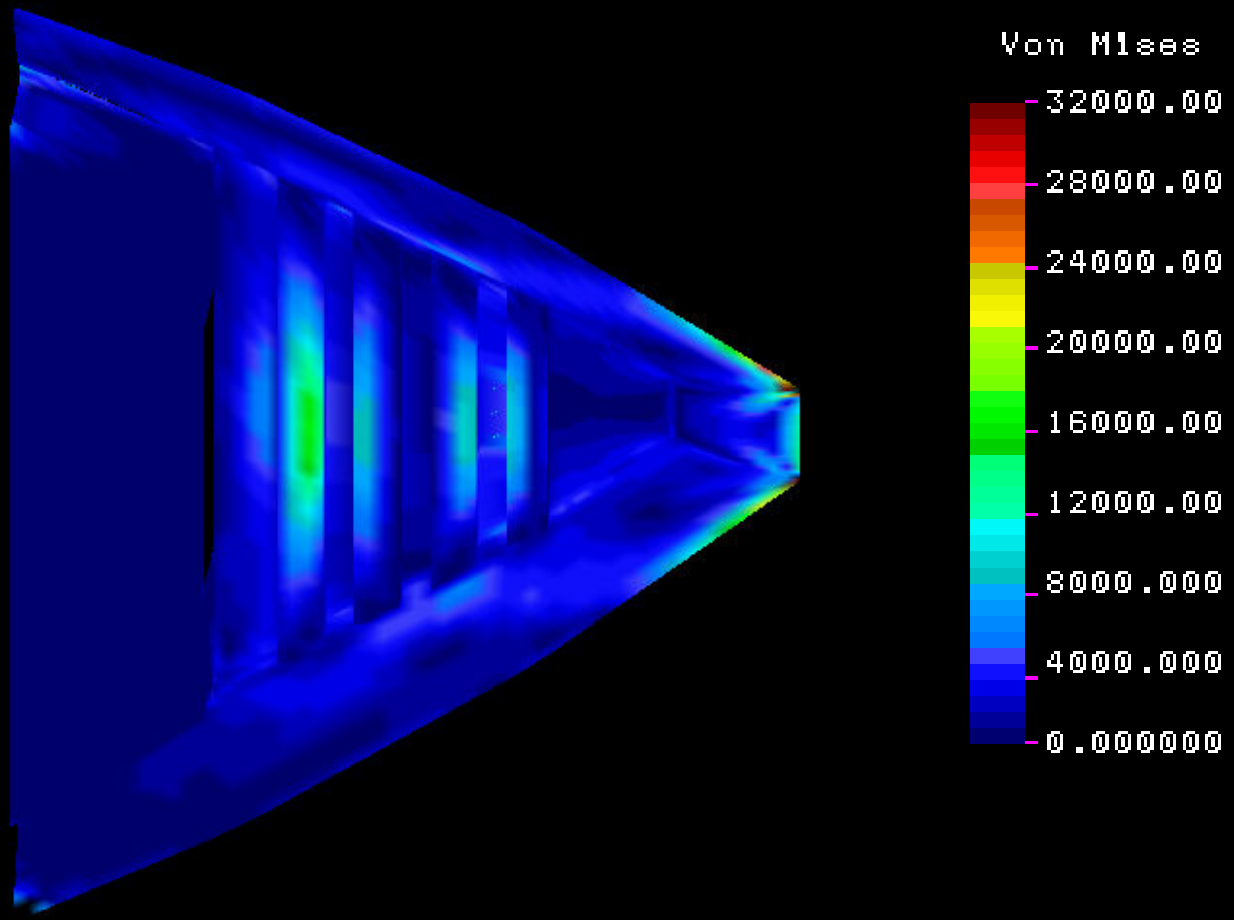
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LC9- GML- Stress in Tran. Ply (Bottom)



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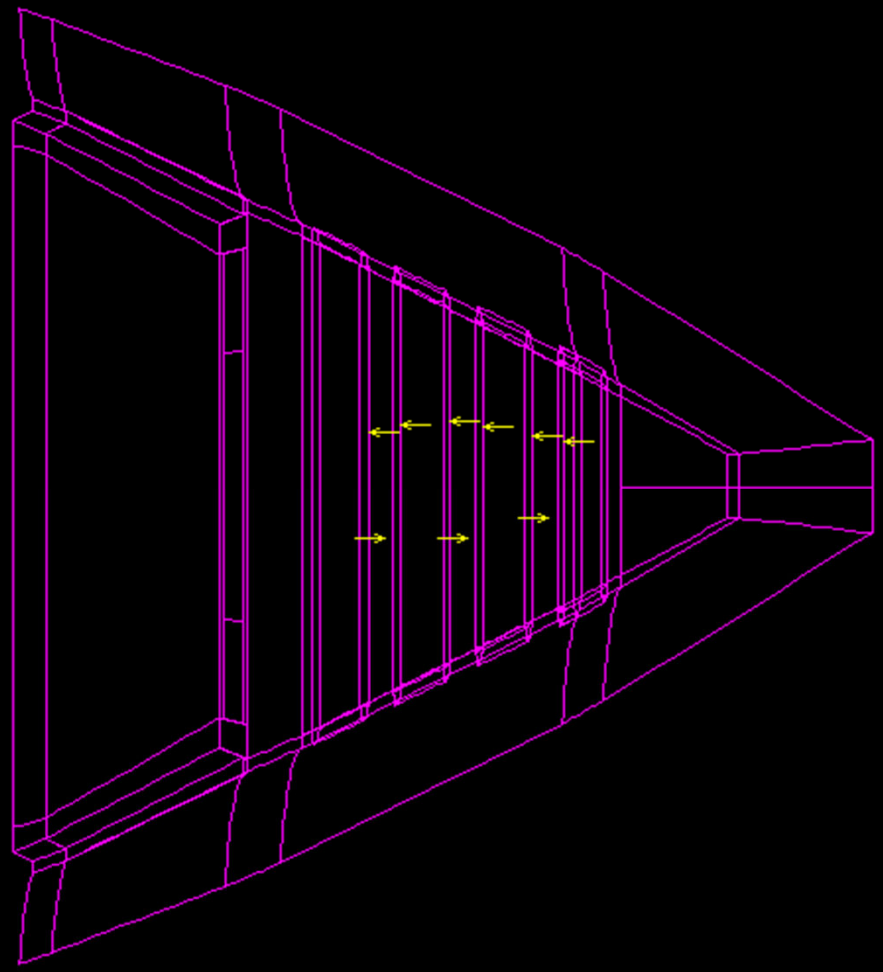
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850A- G.M.L- Summary

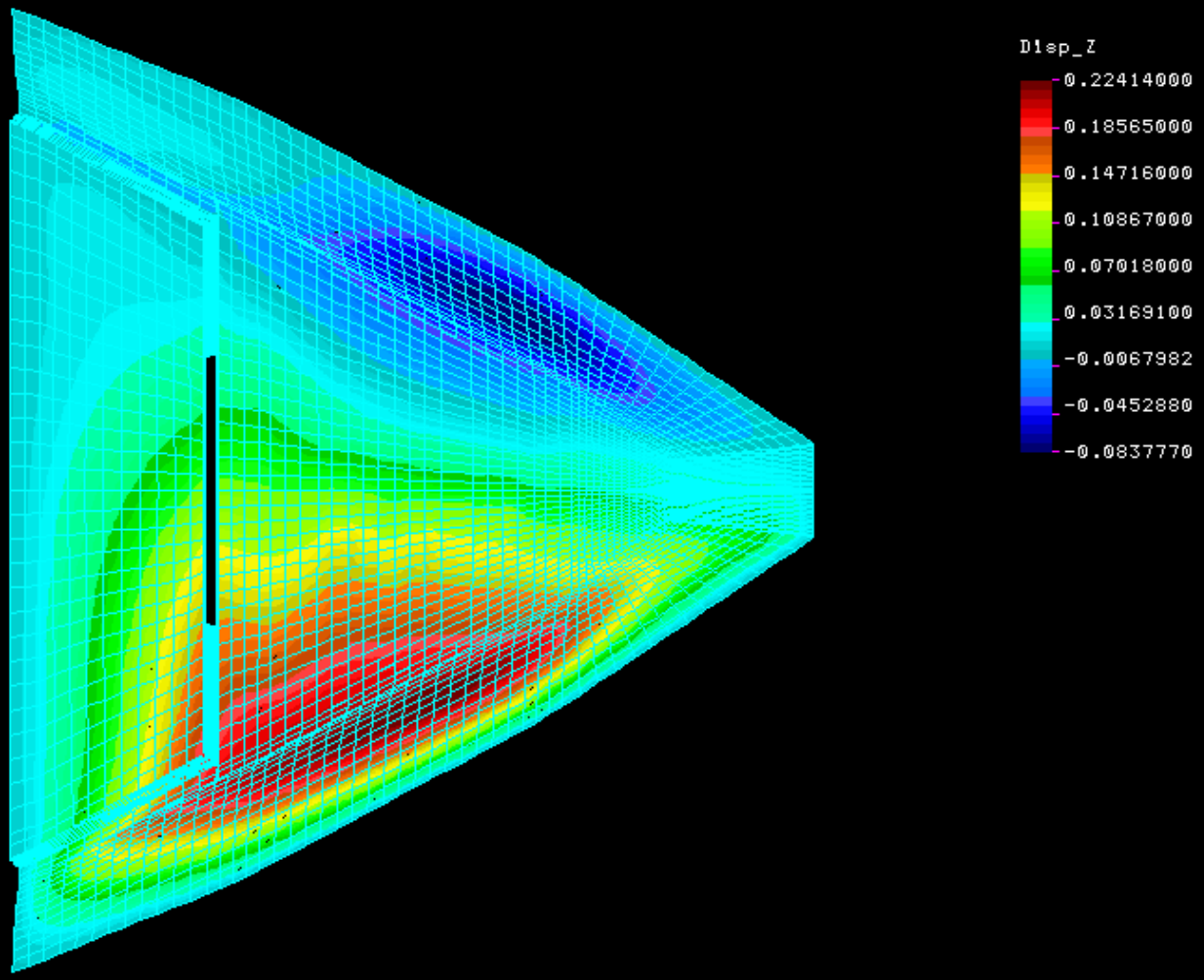
- Range of deflection 0.29 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 15,500 psi

LC10- GMT- Trans. Loading



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LC10- GMT- Z Displacement



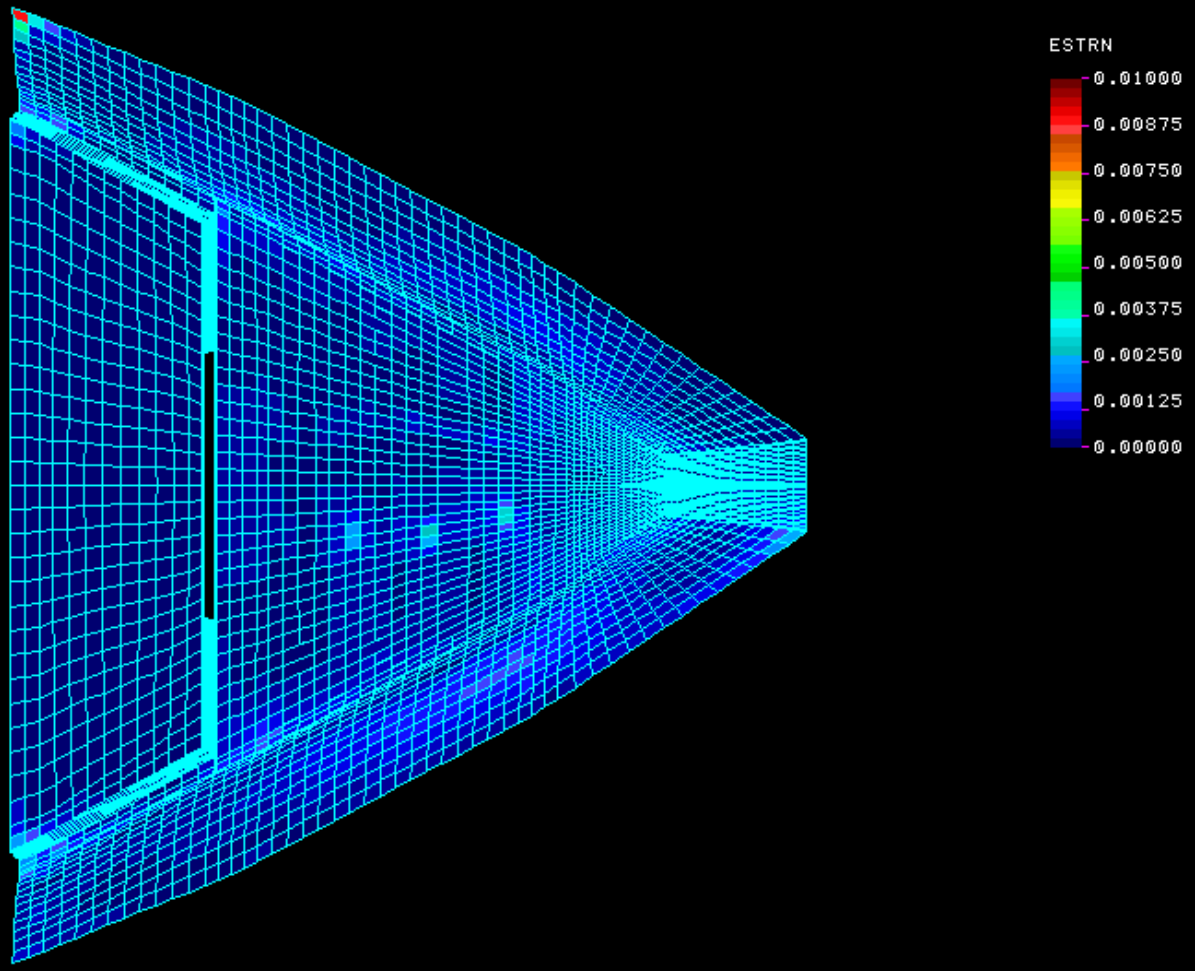
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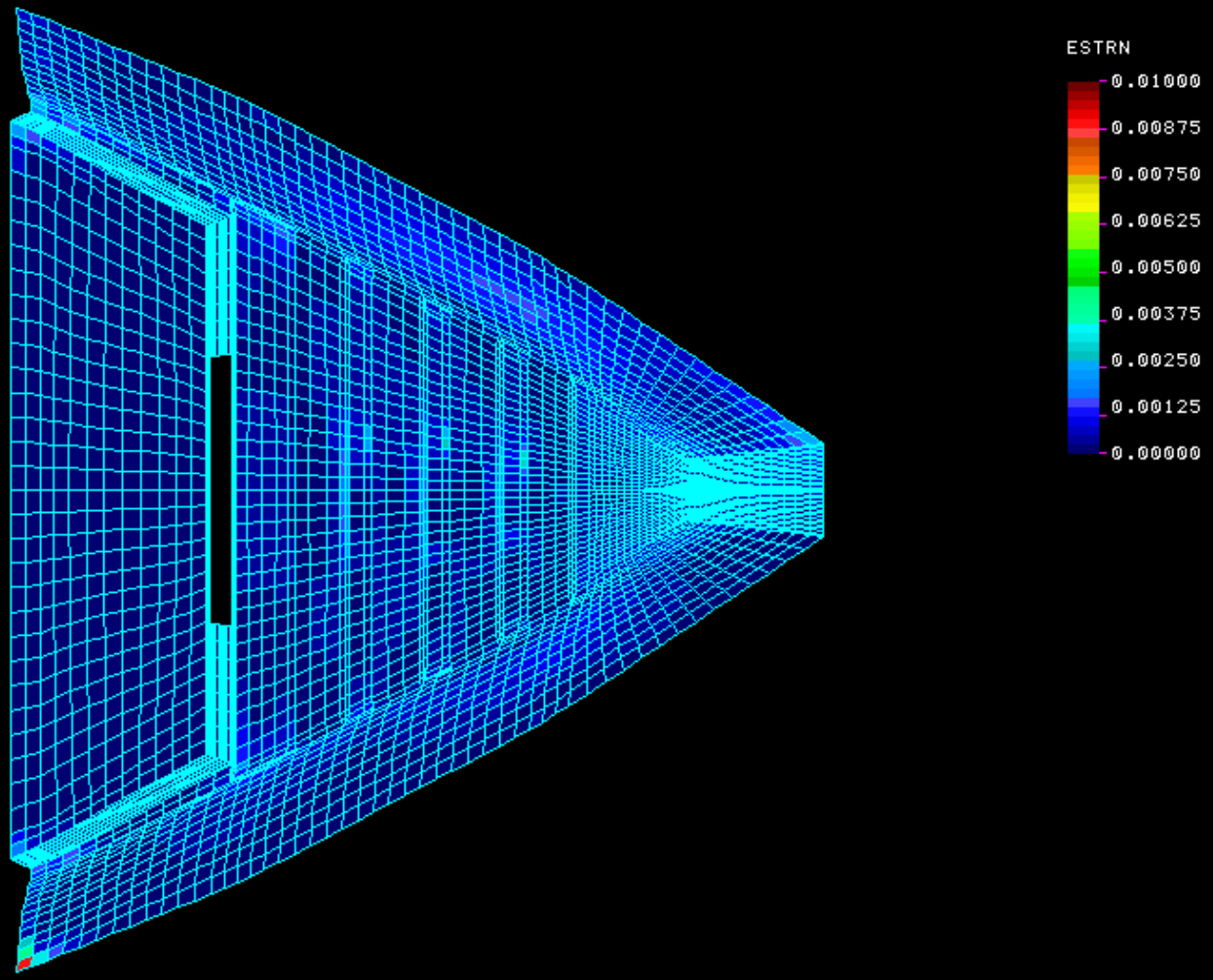
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LC10- GMT- Strain (Top View)



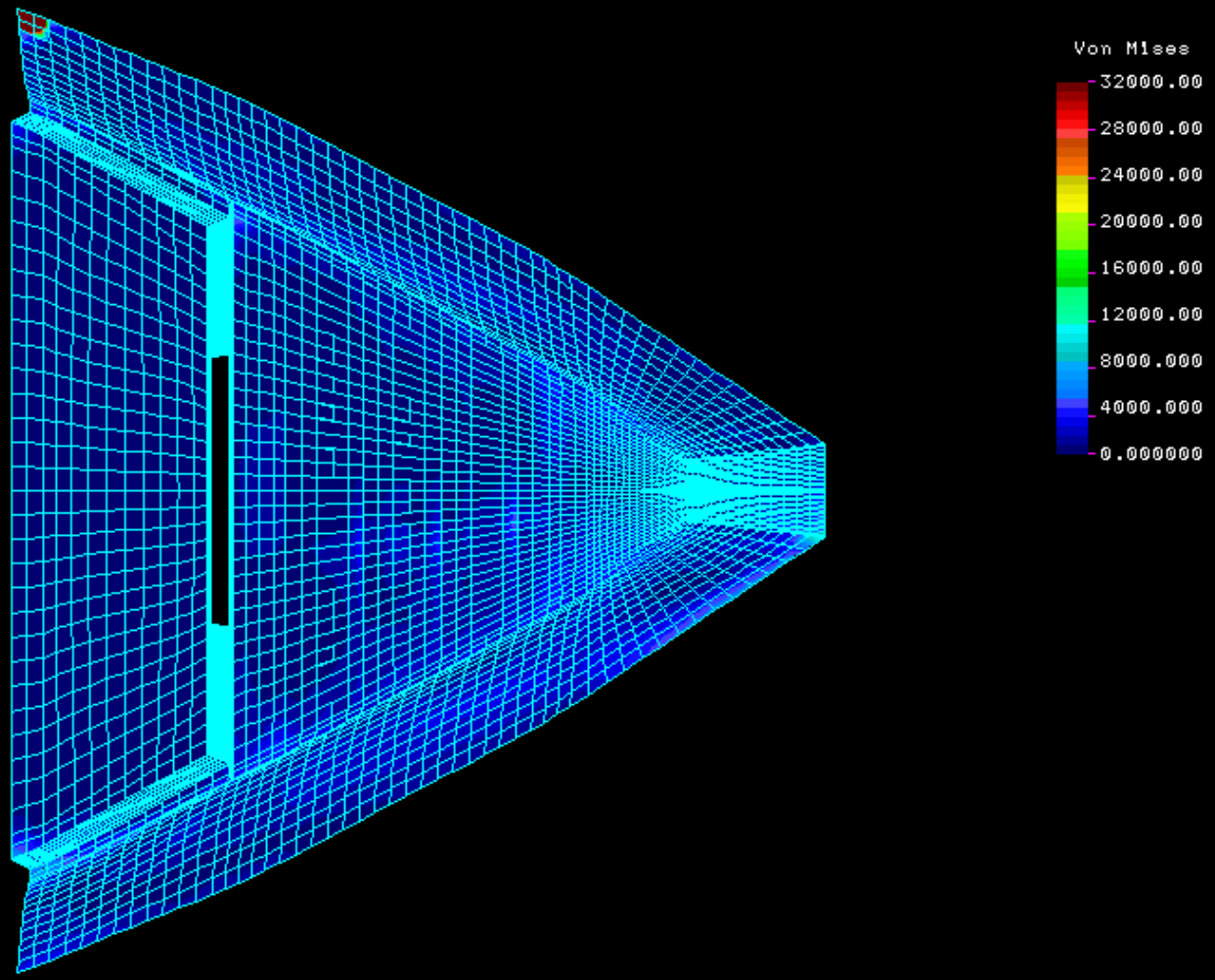
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LC10- GMT- Strain (Bottom View)



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LC10- GMT- Stress in Longitudinal Ply (Top)



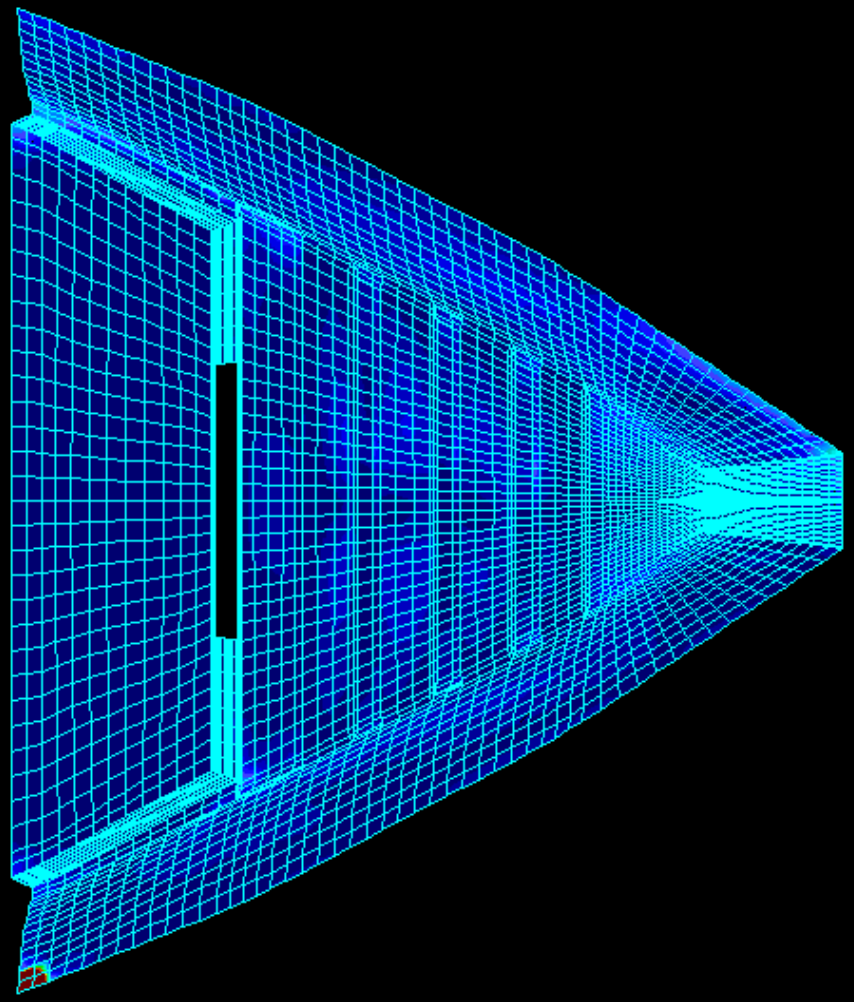
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LC10- GMT- Stress in Long. Ply (Bottom)



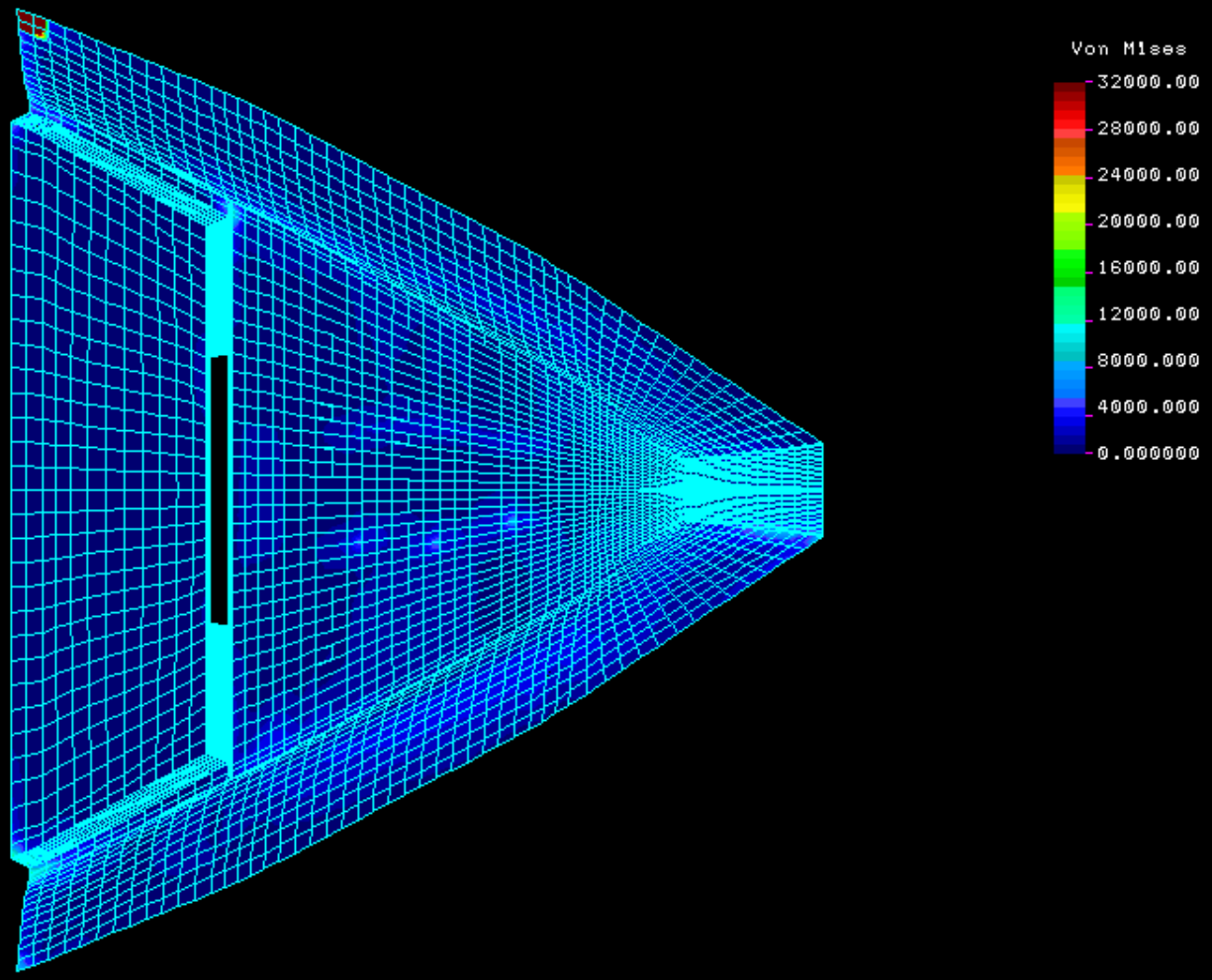
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LC10- GMT- Stress in Tran. Ply (Top)



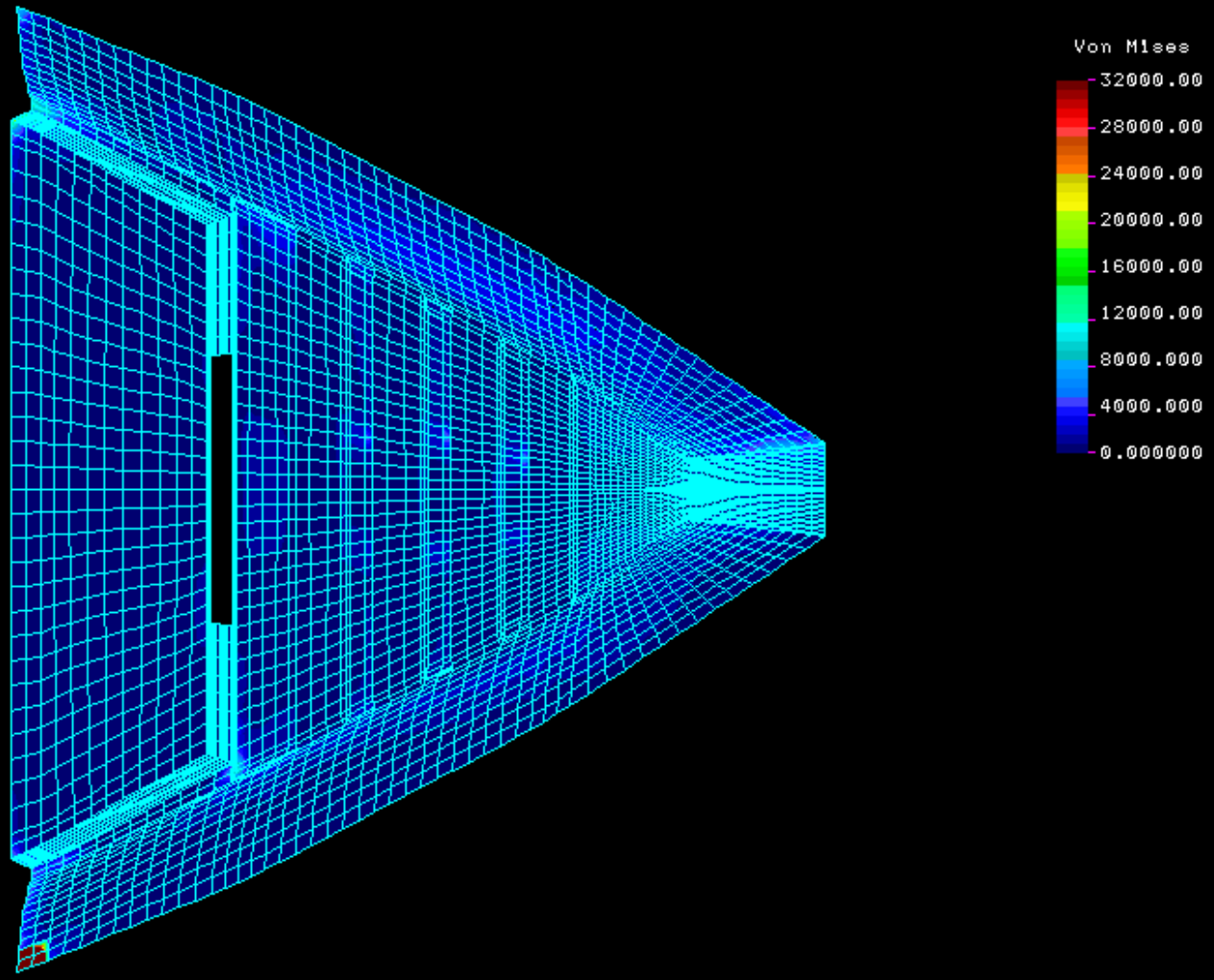
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LC10- GMT- Stress in Tran. Ply (Bottom)



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850A- G.M.T- Summary

- Range of deflection 0.25 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 5,000 psi

Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
  - Slight weight increase from Rev 0
- FOS for strength in excess of 10

Lightweight Shock Mitigation in Naval RIB Hull Structures

SCRA Subcontract #2011-510

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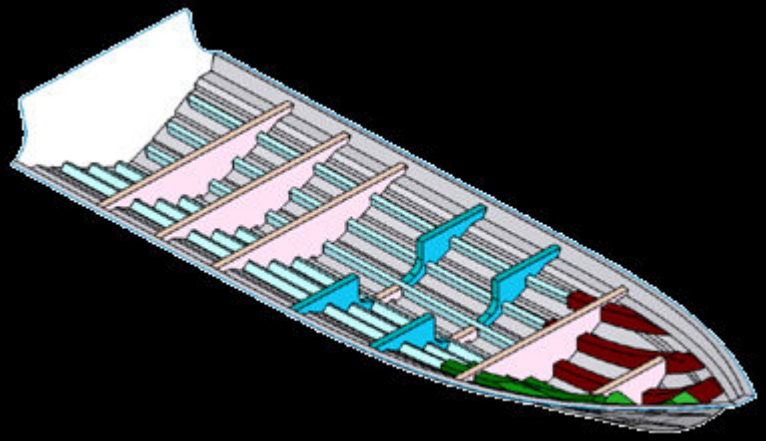
FINAL DESIGN REVIEW
April 2011

IBIF 850A Design Presentation

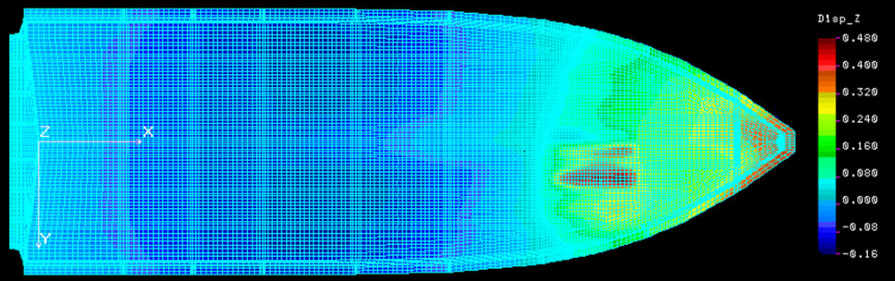
- Contents
  - 850A Rev 2 Design Presentation
  - Weight Estimates 850A, 850B
  - 850A Drawings Package
  - 850A FEA Load Cases

850A Design Presentation

- 850A REV 2 Drawing Package
  - Hull
  - Deck
  - Hatches
  - Tow/Lift/Console



- 850A REV 2 Structural Analysis
  - Wave Load FEA
  - Lift Load FEA



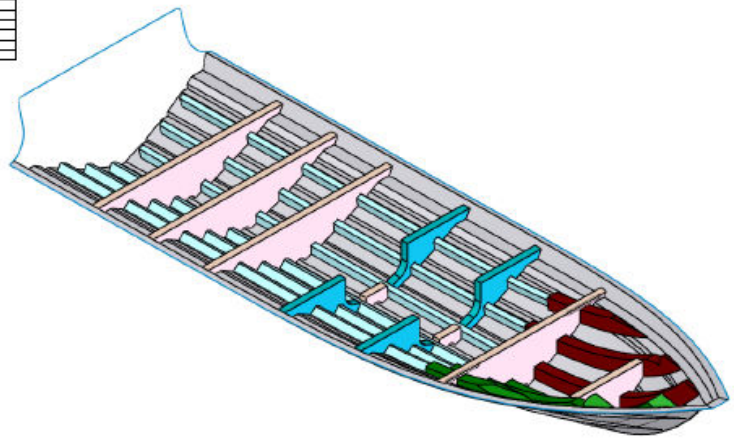
850A- Hull Drawings

BOM

ITEM NO.	QTY	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Grey	
2	A/R	AOC KUZ2-EBB-00 Resin	Alpha Owens Corning	KUZ2-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E-LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/- 45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/- 45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/- 45 fabric
9		not used			
10	A/R	E-LM T810 0 fabric - 3" wide	Vectorply	E-LM T810	0 fabric
11	A/R	3oz Chopped Strand Mat			
12	A/R	26lb Density Core	Acon baltek Corporation	PXC420	1-3/4" thick
13		not used			
14	90 LF	TR40S0A	Compsys	TR40S0A	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850MA-SPOS	
16	1	Starboard Mid Stringer	Compsys	BCG850MA-SPMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850MA-SPIS	
18	1	Port Outboard Stringer	Compsys	BCG850MA-PPOS	
19	1	Port Mid Stringer	Compsys	BCG850MA-PPMS	
20	1	Port Inboard Stringer	Compsys	BCG850MA-PPIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	1	Bulkhead A	Compsys	BCG850MA-BHA	
26	1	Bulkhead B	Compsys	BCG850MA-BHB	
27	2	Bulkhead C-D	Compsys	BCG850MA-BHCD	
28	3	Bulkhead E-F-G	Compsys	BCG850MA-BHE,F,G	
29	2	Bulkhead Wing C (P&S)	Compsys	BCG850MA-PSWC	
30	2	Bulkhead Wing D (P&S)	Compsys	BCG850MA-PSWD	
31	95 LF	FSz2010	Compsys	FSz2010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

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DRAWING TITLE

850A HULL

DATE	4/7/2011
DRAWN	TED BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 850-850A-1 | SHEET 1 OF 5

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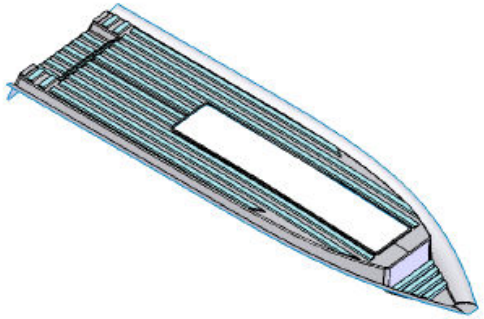
850A- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC KO22-EB8-00 Resin	Alpha Owens Corning	KO22-EB8-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 UNC fabric	Vectorply	E LTM 3610	U90 fabric
5		not used			
6		not used			
7	A/R	E-BXM 2406 +/- 45 fabric	Vectorply	E-BXM 2406	+/-45 fabric
8	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
9	130 LF	TR4010	Compsys	TR4010	
10	10 LF	TR3030X	Compsys	TR3030X	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
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2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850A DECK

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9000-850A-2 | SHEET 1 OF 3

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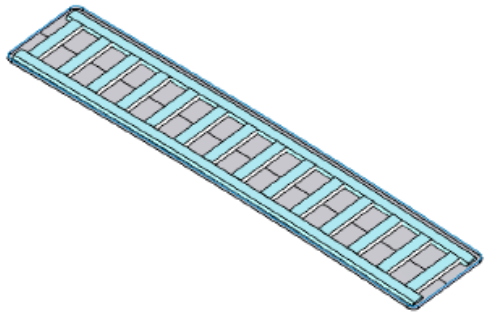
850A- Hatch Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC K022-EBB-00 Resin	Alpha Owens Corning	K022-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
6	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
14	50 LF	TR4010	Compsys	TR4010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850A HATCH

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9020-850A-0 | SHEET 1 OF 3

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850A – Laminate Schedule

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 3 x 3610
- Stringers – TR4030X /1810 / 1208 / 3608
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 3610 / 2408 / 1810 / TR4010 / TR3030X
- Deck Framing – Gel Coat / 2oz CSM / 4 x 3610 / TR4010 / TR3030X / 4 x 1810 / 2408
- Transom – Gel Coat / 2oz CSM / 2 x 3610 / 3oz CSM / 26lb Density Core / 3610

850A - FEA

- FEA Model of 850A Hull/Deck
- Applied Load to Hull Panels
- Deflection and Stress Reactions
- 10 Load Cases Total
  - Small Area Slamming (SAS)
    - Five Load Cases
      - 2 Aft and Fwd panels between bulkheads (Inboard and Outboard)
      - Included Stringer

850A- FEA

- Large Area Slam (LAS)
- Calm Water Planning (CWP)
- Boat Lift Points (BLP)
- Gun Mount
  - Longitudinal (GML)
  - Transverse (GMT)

850A- FEA Load Cases

Load Case	Load ID	Description	Pressure	Load
1	AMI	Aft Mid Inboard, SAS	10psi	--
2	AMO	Aft Mid Outboard, SAS	10psi	--
3	FI	Fwd Inboard, SAS	10psi	--
4	F0	Fwd Outboard, SAS	10psi	--
5	STR	Stringer, SAS	10psi	--
6	LAS	Large Area Slam	4.68psi	44,000lbs
7	CWP	Calm Water Planning	1.1psi	11,000lbs
8	BLP	Boat Lift Points	--	10,860lbs
9	GML	Gun Mount-Longitudinal	--	1500lbs
10	GMT	Gun Mount-Transverse	--	1500lbs

850A- FEA Analysis Overview











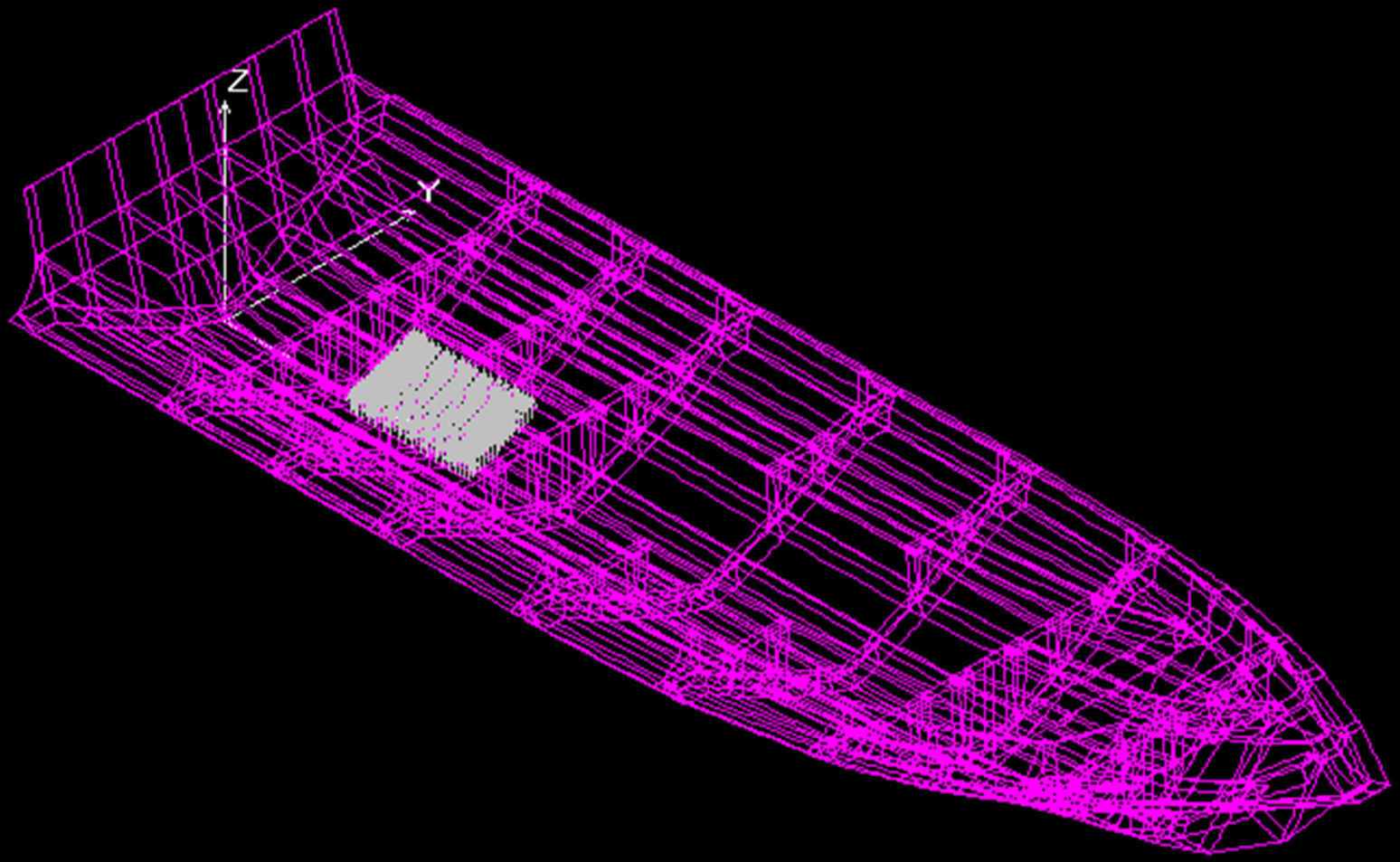
850A- FEA Analysis: Small Area Slamming (SAS)



Small Area Pressure Load

- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

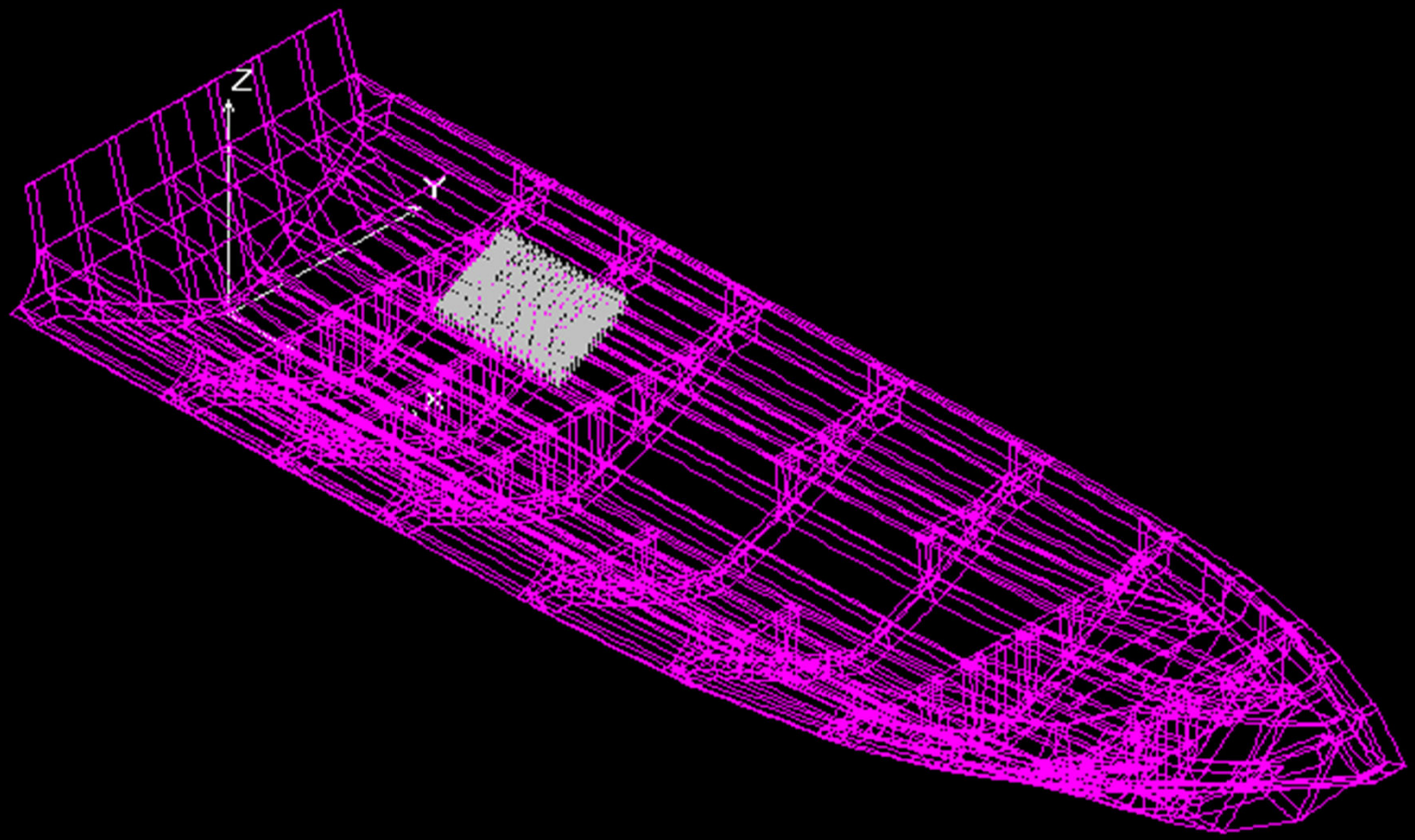
LC1- AMI-10 psi Pressure Load



LC1- AMI- Summary

- Deck range of deflection 0.30 in.
- Hull range of deflection 0.44 in.
- Local panel deflection 0.165 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 9,000 psi
- Maximum hull shell stress 5,000 psi

LC2- AMO-10 psi Pressure Load

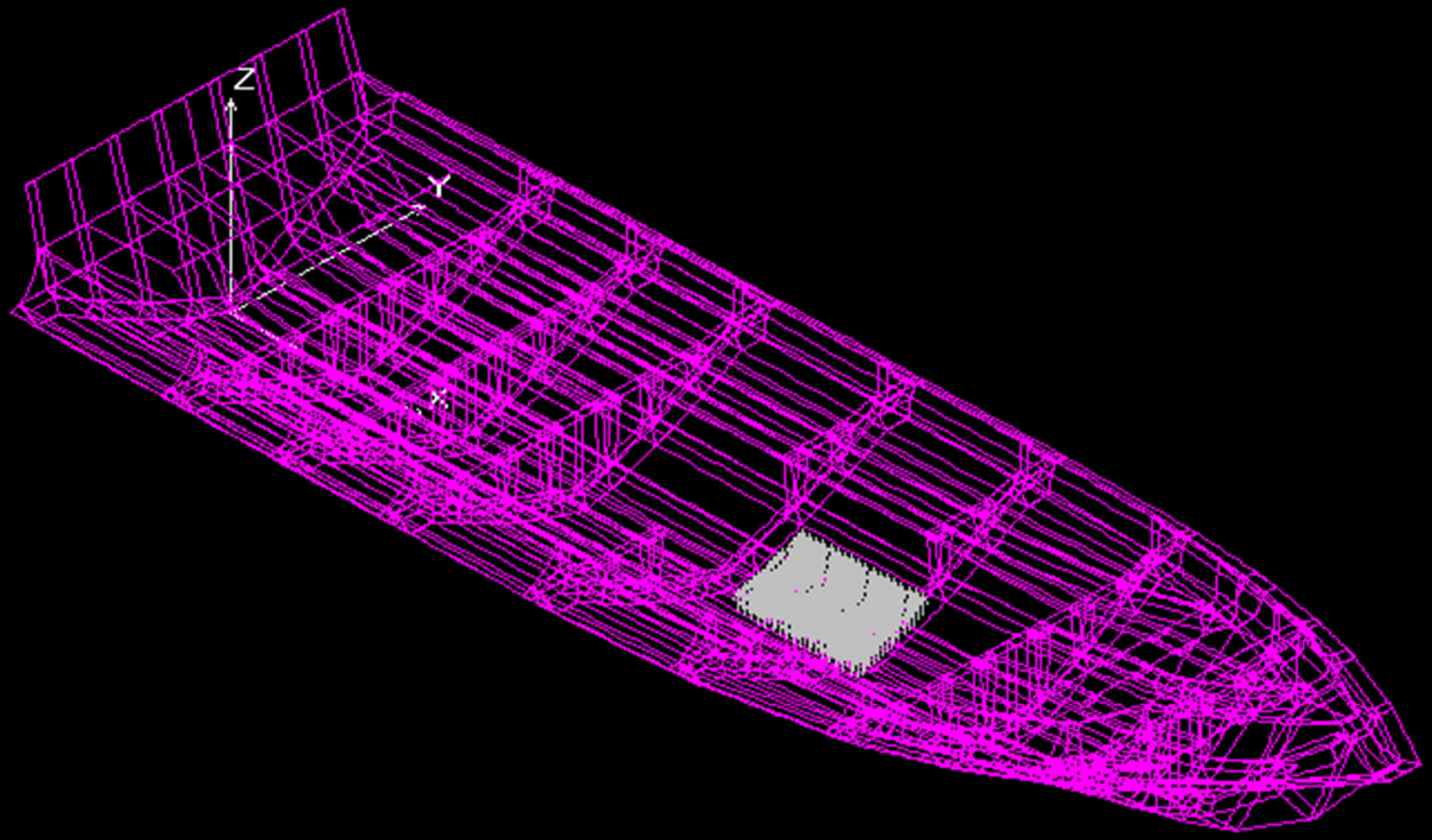


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LC2- AMO- Summary

- Deck range of deflection 0.56 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.17 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 10,500 psi
- Maximum hull shell stress 7,000 psi

LC3- FI-10 psi Pressure Load

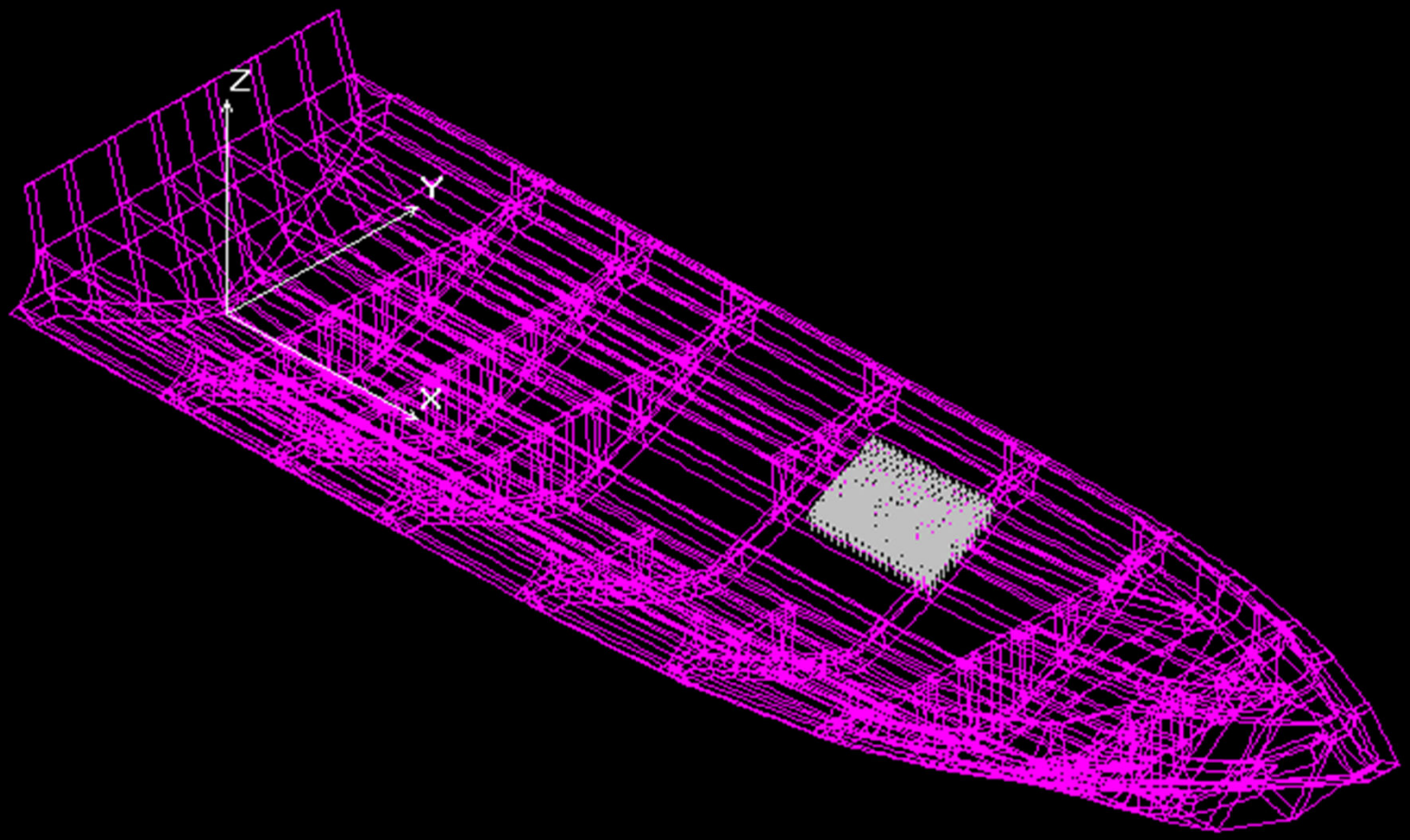


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LC3- FI- Summary

- Deck range of deflection 0.8 in.
- Hull range of deflection 0.8 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC4- FO-10 psi Pressure Load

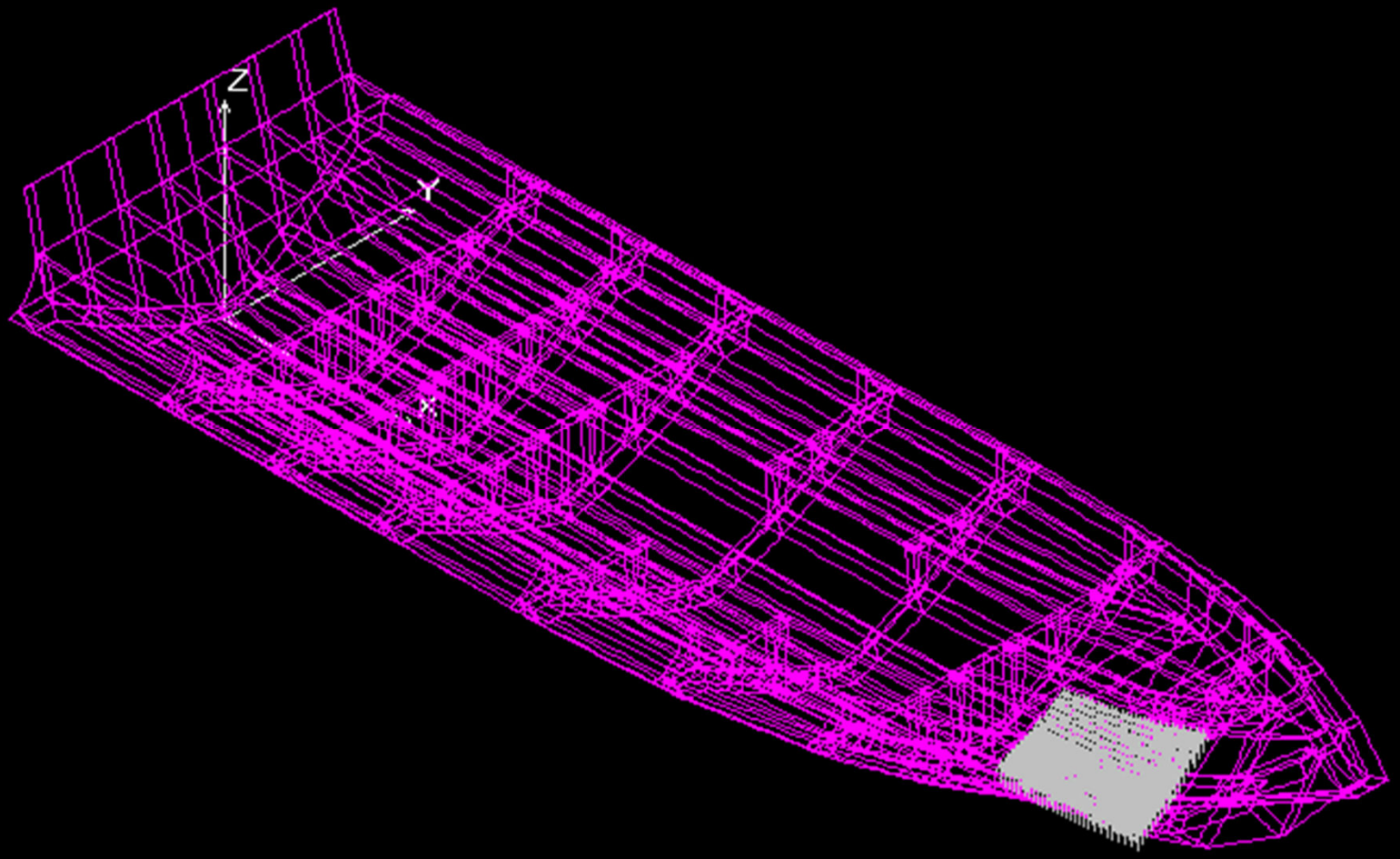


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LC4- FO- Summary

- Deck range of deflection 0.69 in.
- Hull range of deflection 1.0 in.
- Local panel deflection 0.36 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 19,000 psi
- Maximum hull shell stress 5,500 psi

LC5- STR-10 psi Pressure Load



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LC5- STR- Summary

- Deck range of deflection 0.52 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0035 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC(1-5)- SAS Summary

Range of maximum values in SAS cases

- Deck range of deflection 0.30-0.69 in.
- Hull range of deflection 0.44-1.0 in.
- Local panel deflection 0.16-0.36 in.
- Maximum strain 0.002-0.0035 in/in
- Maximum framing stress 9,000-19,000 psi
- Maximum hull shell stress 5,000-8,000 psi

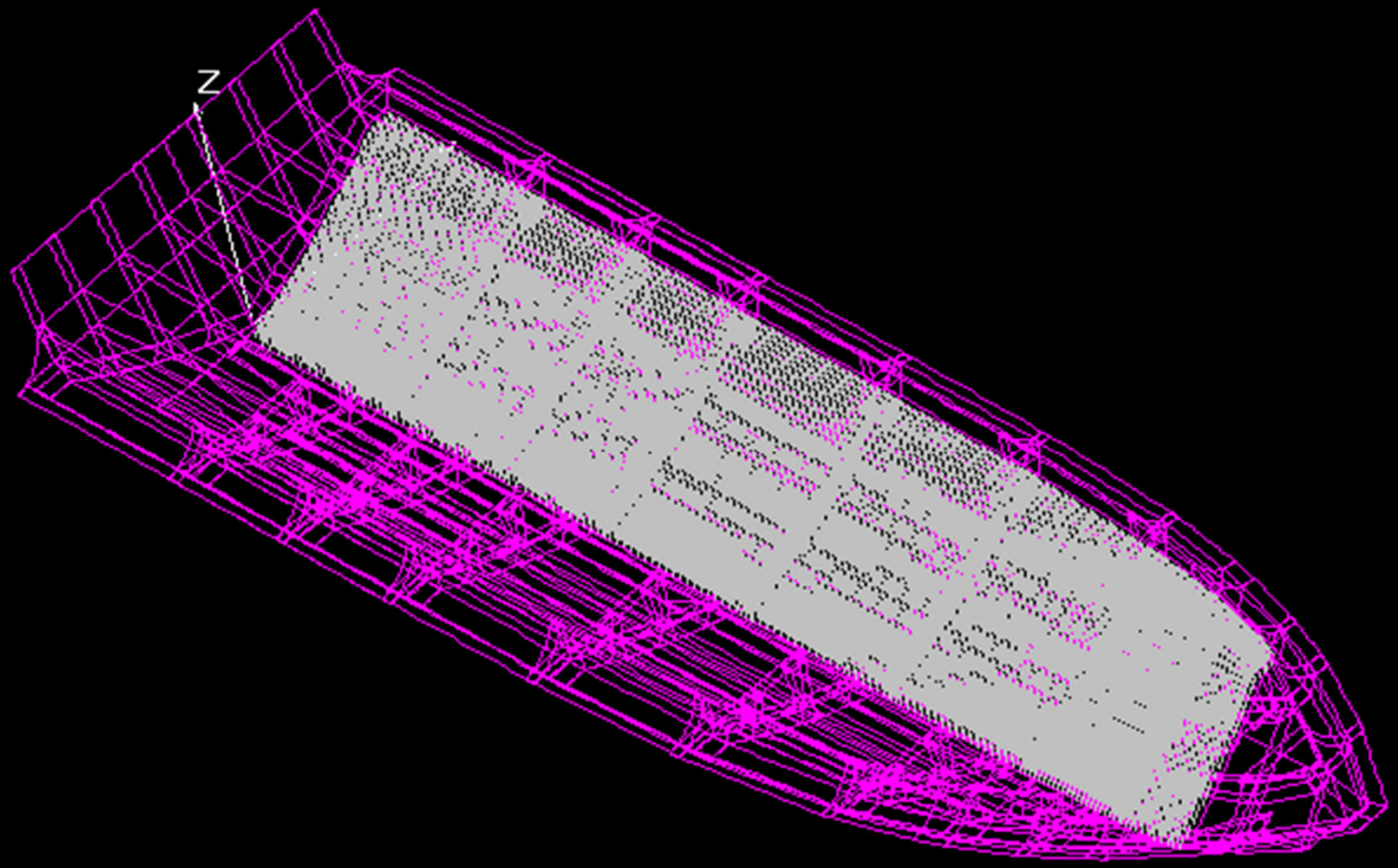
850A- FEA Analysis: Large Area Slam (LAS)



LC6-LAS- Loading

- Pressure load 4.68 psi
- Total load 44,000 lbs
- 11,000 lbs running weight at 4 g's

LC6-LAS- 4.68psi Pressure Load



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850A- LAS Summary

- Deck range of deflection 1.72 in.
- Hull range of deflection 2.19 in
- Local panel deflection 0.17 in.
- Maximum strain 0.025 in/in
- Maximum longitudinal stress 13,500 psi
- Maximum transverse stress 12,000 psi

850A- FEA Analysis: Calm Water Planning (C.W.P.)

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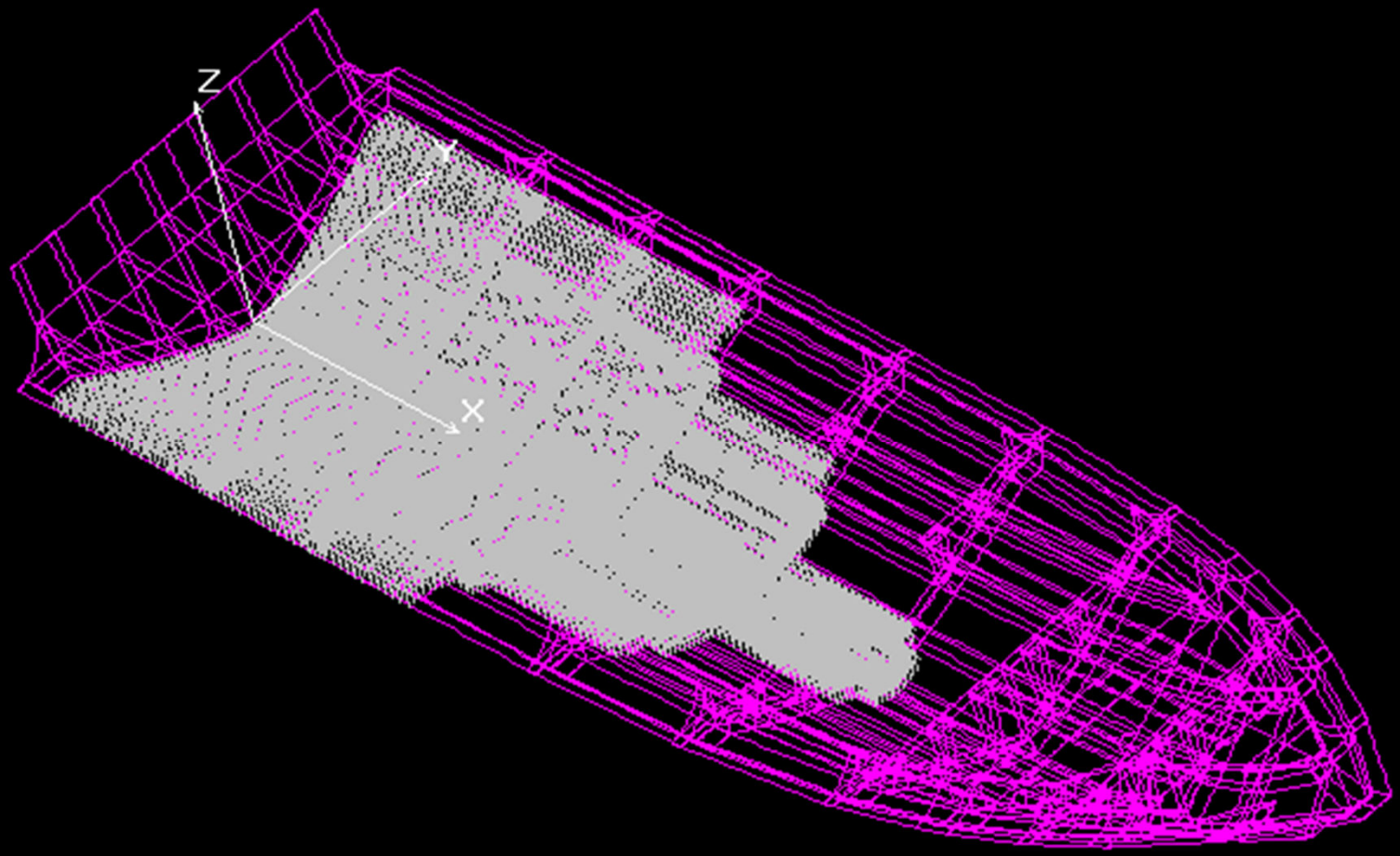
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LC7-CWP- Load

- Boat weight 11,000 lbs
- Bottom pressure 1.1 psi (11,000 lbs total)

LC7-CWP- 1.1psi Pressure Load



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850A- CWP Summary

- Range of deflection 0.52 in.
- Local panel deflection 0.025 in
- Maximum strain 0.0007 in/in
- Maximum longitudinal stress 2000 psi
- Maximum transverse stress 1800 psi

850A- FEA Analysis: Boat Lifting Points (B.L.P.)

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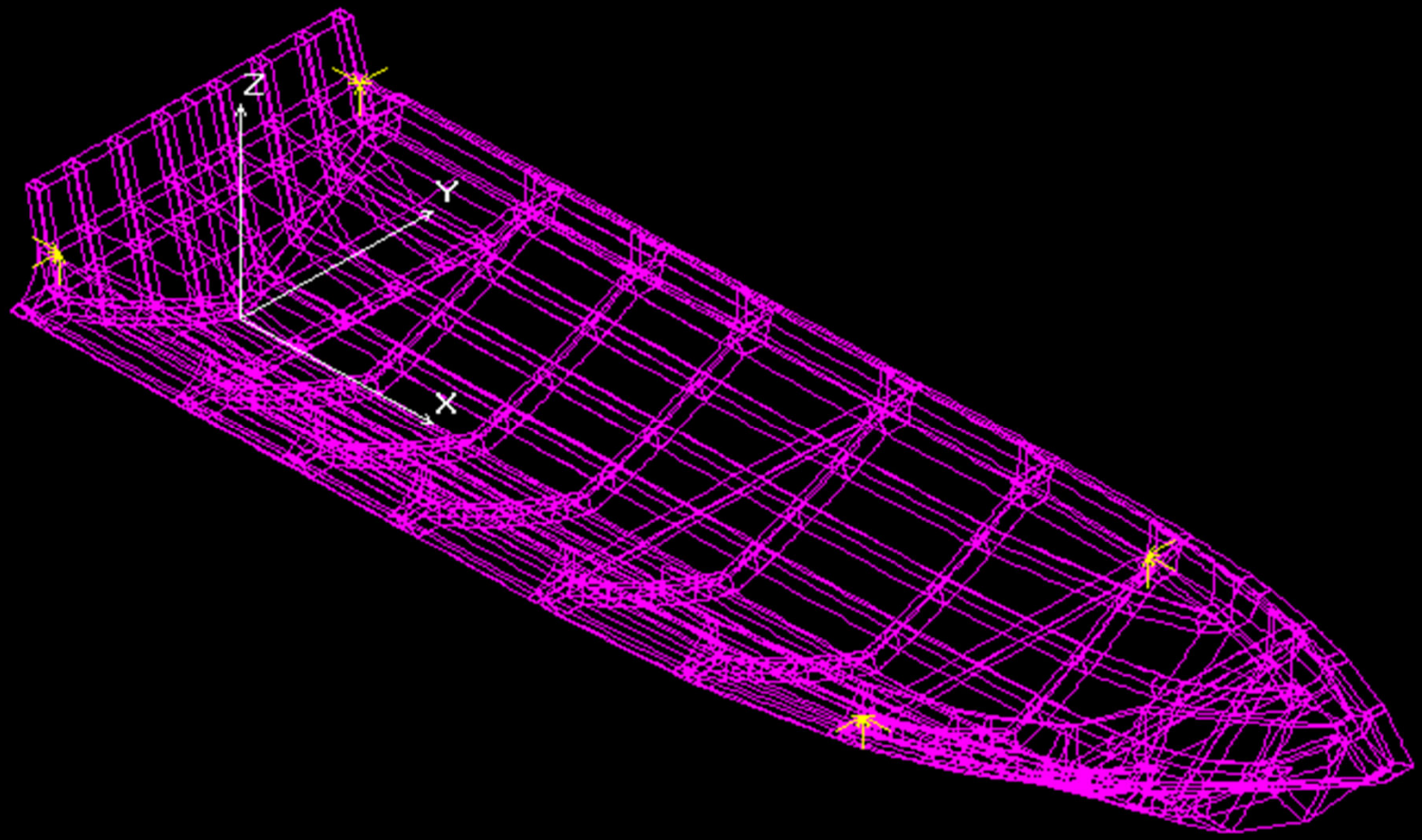
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
  - Redesigned to accommodate tube mounting.
  - Positioned for design LCG

LC8- BLP- Load Data

- Lift weight 7240, SF 6
- 4 point lift
- F_z all four lift points +10860 lbs
- F_x at aft two lift points +3430 lbs
- F_x at fwd two lift points -3430 lbs
- F_y at stbd two lift points +1300 lbs
- F_y at port two lift points -1300 lbs

LC8- BLP- Force Vector at Lift Points



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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints $F_r < 1$ lb
- Thus constraints do not affect results

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LC8- BLP- Lift Analysis Summary

- Model shows structure is adequate for this load case
- FOS: 6
- Range of deflection 1.7 in.
- Maximum strain at lift points 0.0067 in/in
- Maximum longitudinal stress 20,000 psi
- Maximum transverse stress 24,500 psi

850A- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

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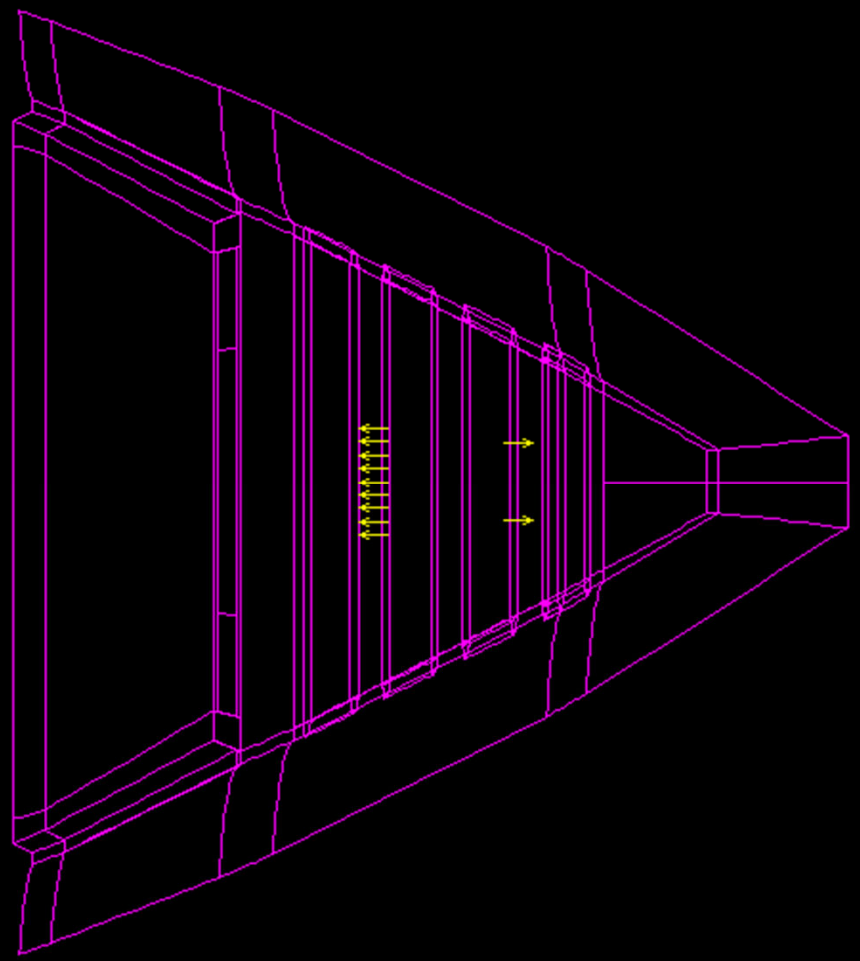
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Gun Mount Framing Notes

- Four transverse frames, TR3030X, are placed on five inch centers
- Skin laminate is four layers of 3610
- Frame laminate:
  - 24 oz (+/-45) on PRISMA Beam
  - 4 layers 1810 warp uni
  - 2408 (+/-45) cover fabric

LC9- GML- Long. Loading

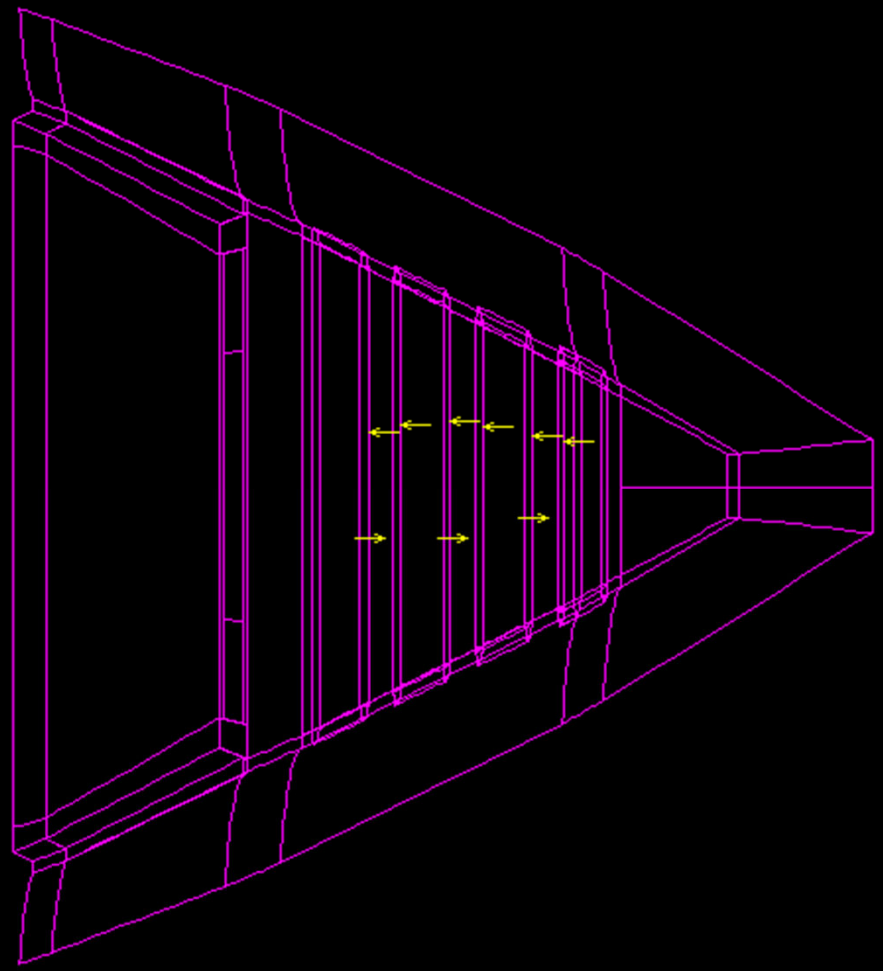


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850A- G.M.L- Summary

- Range of deflection 0.29 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 15,500 psi

LC10- GMT- Trans. Loading



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850A- G.M.T- Summary

- Range of deflection 0.25 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 5,000 psi

Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
  - Slight weight increase from Rev 0
- FOS for strength in excess of 10

Weight Projection 850A

A-Boat					
	Area (sqft)	Weight/Area oz/sqft	Weight (lb)	Rev 1 mod	Rev 2 (lb)
Hull	219.7	43.5	**597**	**18.5**	**616**
Deck	185.5	32.5	**377**	**26**	**403**
Hatch	32.1	32.5	**65**		**65**
Bulkheads	82.8	6	**31**		**31**
			1070		**1115**
	Length (ft)	**Weight/Length (oz/ft)**	**Weight (lb)**	**Rev 1 mod**	**Rev 2 (lb)**
Hull - TR4030	125	15.3	**119**		**119**
Deck - TR4010	130	6.0	**49**		**49**
Hatch TR4010	46	6.0	**17**		**17**
			185		**185**
		Rev 0	**1256**	**Rev 2**	**1300**
		Use Rev 0	**1381**	**Use Rev2**	**1430**

Weight Evaluation- Baseline

Boat Weights (lb)				
Segment	Baseline	850 A	850 B	850 B-OM
Fabrication Method	Open Mold	Open Mold	VARTM	Open Mold
Hull	1115	843	717	789
Deck	665	587	481	529
Console	540	350	350	350
Total	2320	1780	1548	1668
% Current	100%	77%	67%	72%
% Savings	--	23%	33%	28%

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 850A- Exceeds Metrics, On Target
  - 850B- Exceeds Metrics, On Target

850A- Extended Drawings and FEA Analysis Slides



850A- Complete Drawings Package

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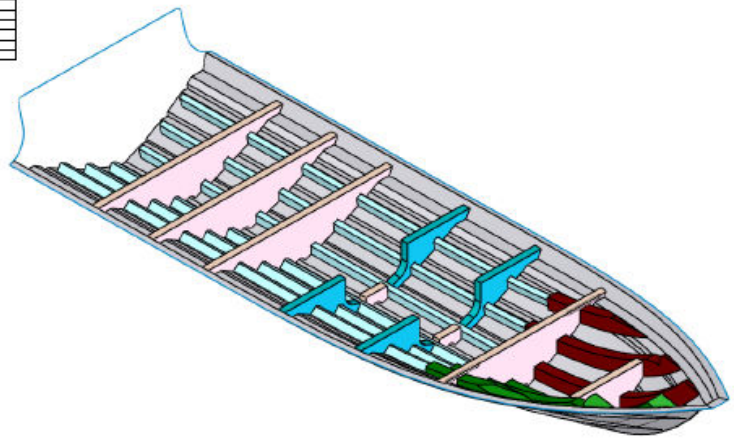
850A- Hull Drawings

BOM

ITEM NO.	QTY	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Grey	
2	A/R	AOC KUZ2-EBB-00 Resin	Alpha Owens Corning	KUZ2-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E-LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/- 45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/- 45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/- 45 fabric
9		not used			
10	A/R	E-LM T810 0 fabric - 3" wide	Vectorply	E-LM T810	0 fabric
11	A/R	3oz Chopped Strand Mat			
12	A/R	26lb Density Core	Acon baltek Corporation	PXC420	1-3/4" thick
13		not used			
14	90 LF	TR40S0A	Compsys	TR40S0A	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850MA-SPOS	
16	1	Starboard Mid Stringer	Compsys	BCG850MA-SPMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850MA-SPIS	
18	1	Port Outboard Stringer	Compsys	BCG850MA-PPOS	
19	1	Port Mid Stringer	Compsys	BCG850MA-PPMS	
20	1	Port Inboard Stringer	Compsys	BCG850MA-PPIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	1	Bulkhead A	Compsys	BCG850MA-BHA	
26	1	Bulkhead B	Compsys	BCG850MA-BHB	
27	2	Bulkhead C+D	Compsys	BCG850MA-BHC/D	
28	3	Bulkhead E-F-G	Compsys	BCG850MA-BHE,F,G	
29	2	Bulkhead Wing C (P&S)	Compsys	BCG850MA-PSWC	
30	2	Bulkhead Wing D (P&S)	Compsys	BCG850MA-PSWD	
31	95 LF	FSu2010	Compsys	FSu2010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE: 850A HULL

DATE: 4/7/2011
DRAWN: TEB/BALTAZAR
CHECKED: XXXXXXXXXXX
APRVD: XXXXXXXXXXX

SCALE: NTS | JOB No. | DWG No. 850-850A-1 | SHEET 1 OF 5 | REV

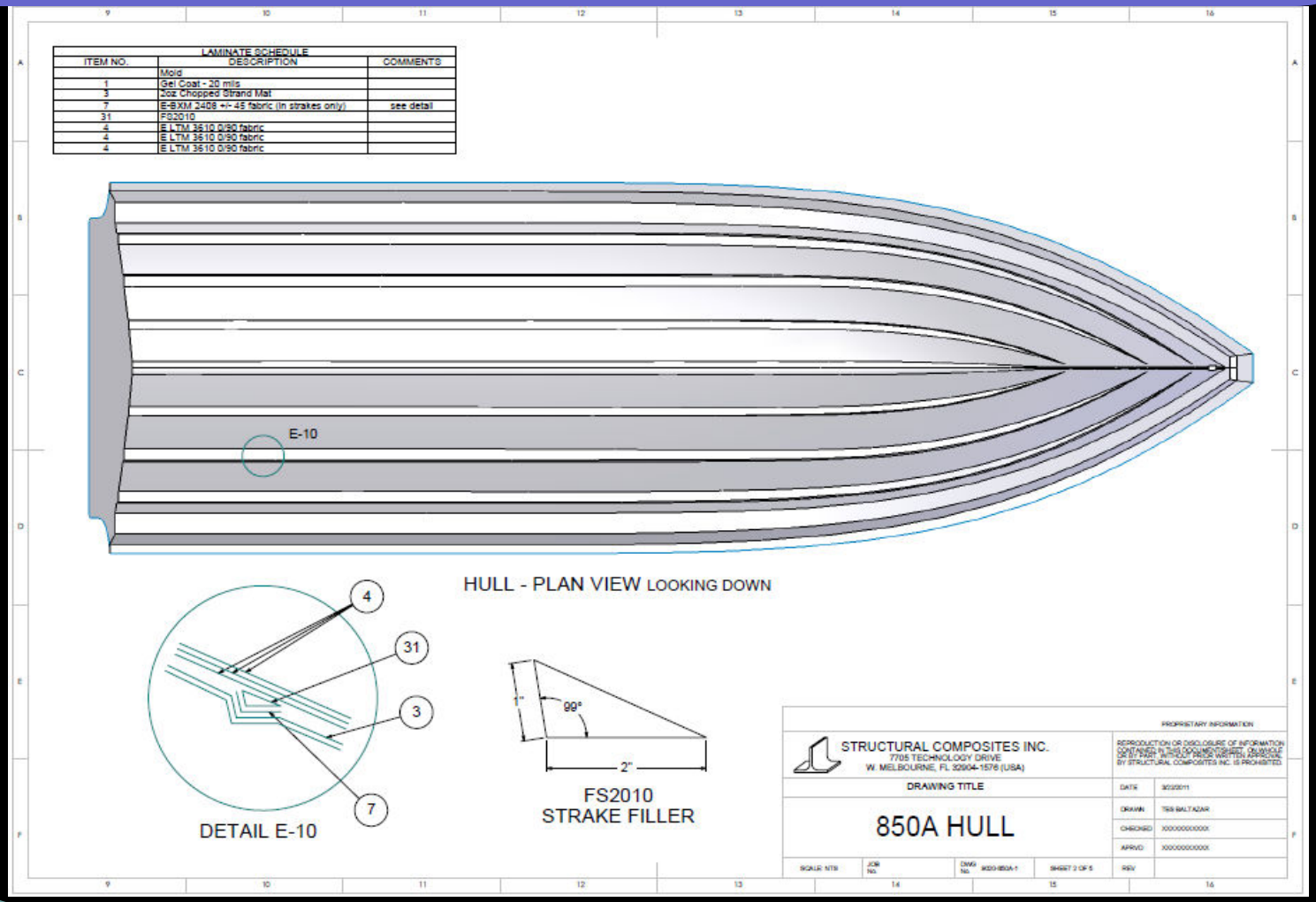
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850A- Hull Drawings- BOM

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/- 45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/- 45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/- 45 fabric
9		not used			
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
11	A/R	3oz Chopped Strand Mat			
12	A/R	26lb Density Core	Alcan Baltek Corporation	PXC420	1-3/4" thick
13		not used			
14	90 LF	TR4030X	Compsys	TR4030X	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850IMA-SFOS	
16	1	Starboard Mid Stringer	Compsys	BCG850IMA-SFMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850IMA-SFIS	
18	1	Port Outboard Stringer	Compsys	BCG850IMA-PFOS	
19	1	Port Mid Stringer	Compsys	BCG850IMA-PFMS	
20	1	Port Inboard Stringer	Compsys	BCG850IMA-PFIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	1	Bulkhead A	Compsys	BCG850IMA-BH7	
26	1	Bulkhead B	Compsys	BCG850IMA-BH6	
27	2	Bulkhead C-D	Compsys	BCG850IMA-BH4,5	
28	3	Bulkhead E-F-G	Compsys	BCG850IMA-BH1,2,3	
29	2	Bulkhead Wing C (P&S)	Compsys	BCG850IMA-P/SW2	
30	2	Bulkhead Wing D (P&S)	Compsys	BCG850IMA-P/SW1	
31	95 LF	FS2010	Compsys	FS2010	

850A- Hull Drawings



LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
3	2oz Chopped Strand Mat	
7	E-BXM 2408 +/- 45 fabric (In strakes only)	see detail
31	FS2010	
4	E LTM 3610 0/90 fabric	
4	E LTM 3610 0/90 fabric	
4	E LTM 3610 0/90 fabric	

HULL - PLAN VIEW LOOKING DOWN

DETAIL E-10

FS2010
STRAKE FILLER

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SCALE: NTS	
JOB No.	
DWG No.	9000-850A-1
SHEET 2 OF 5	
REV	

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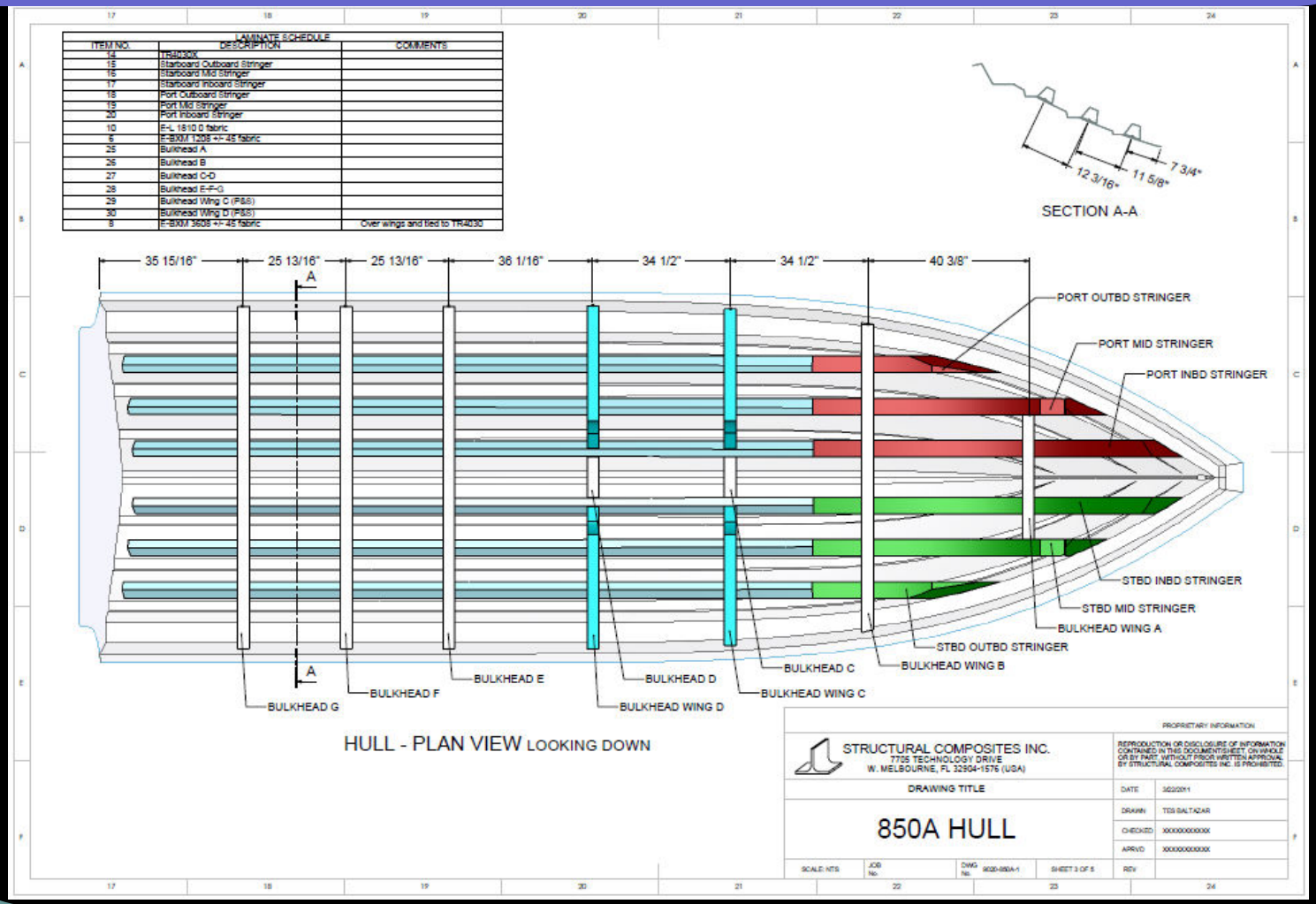
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850A- Hull Drawings



LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
14	TR4030X	
15	Starboard Outboard Stringer	
16	Starboard Mid Stringer	
17	Starboard Inboard Stringer	
18	Port Outboard Stringer	
19	Port Mid Stringer	
20	Port Inboard Stringer	
10	E-L 1810 0 fabric	
6	E-BXM 1208 +/- 45 fabric	
25	Bulkhead A	
26	Bulkhead B	
27	Bulkhead C-D	
28	Bulkhead E-F-G	
29	Bulkhead Wing C (P&S)	
30	Bulkhead Wing D (P&S)	
8	E-BXM 3608 +/- 45 fabric	Over wings and tied to TR4030

SECTION A-A

HULL - PLAN VIEW LOOKING DOWN

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850A HULL

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APRVD	XXXXXXXXXXX
REV	

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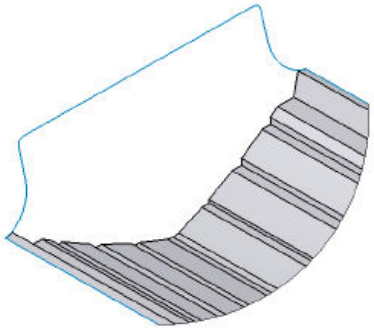
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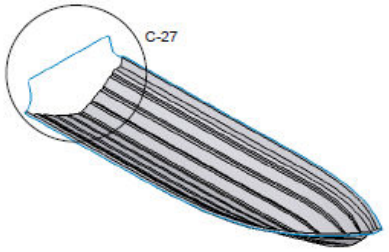
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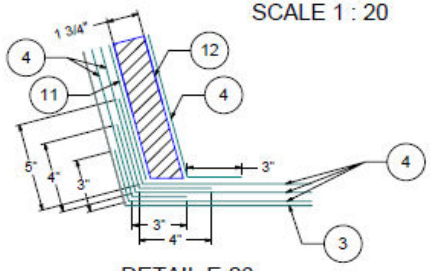
850A- Hull Drawings

LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
3	2oz Chopped Strand Mat	
4	E LTM 3610 D/90 fabric	
4	E LTM 3610 D/90 fabric	
11	3oz Chopped Strand Mat	
12	26lb Density Core	
4	E LTM 3610 D/90 fabric	



DETAIL C-27
SCALE 1 : 20





DETAIL E-26

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DRAWING TITLE

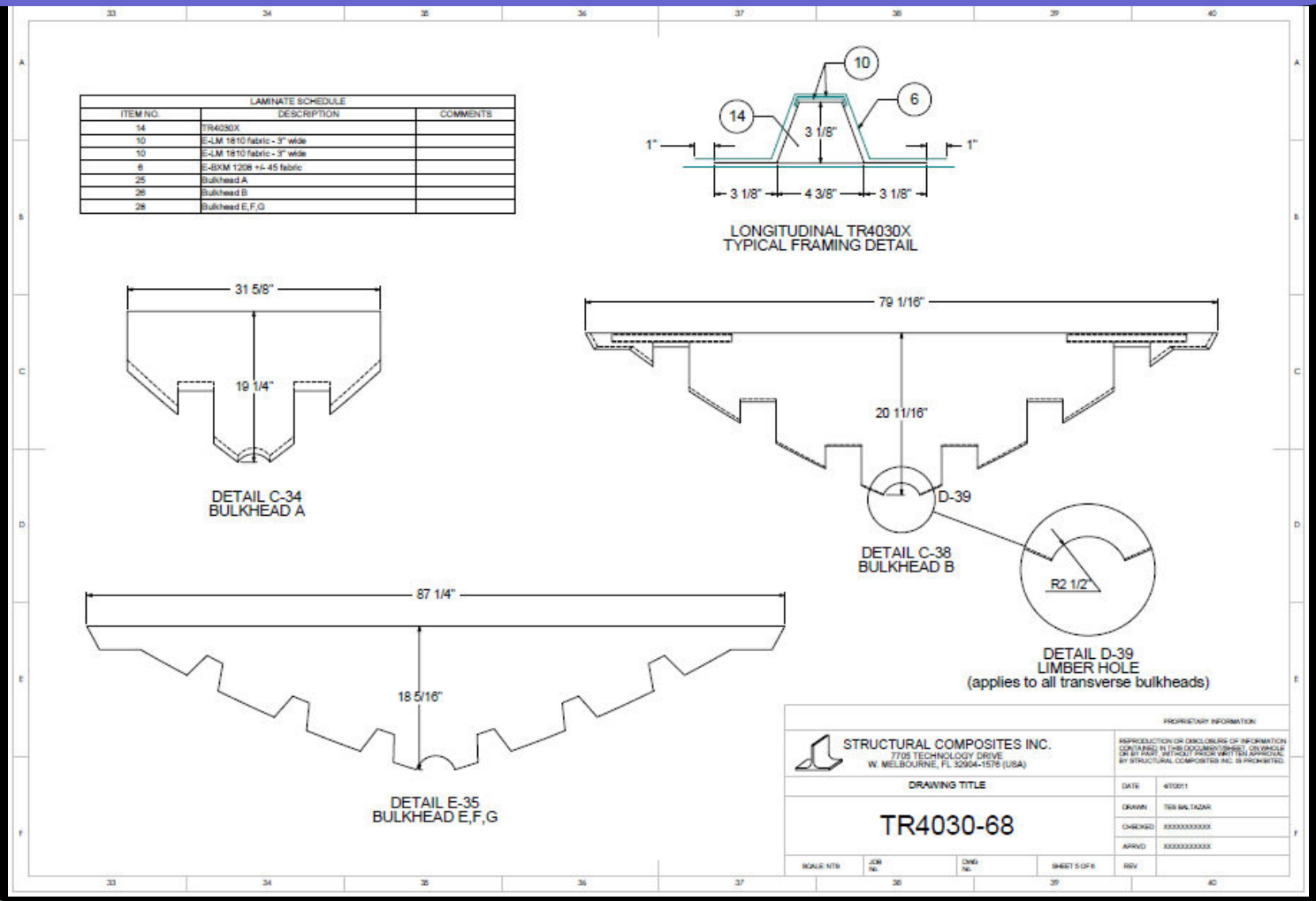
850A HULL

DATE	3/25/2011
DRAWN	TEG GALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9020-850A-1 | SHEET 4 OF 5

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850A- Hull Drawings



LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
14	TR4030X	
10	E-LM 1810 fabric - 3" wide	
10	E-LM 1810 fabric - 3" wide	
6	E-BXM 1208 +/- 45 fabric	
25	Bulkhead A	
26	Bulkhead B	
28	Bulkhead E,F,G	

LONGITUDINAL TR4030X
TYPICAL FRAMING DETAIL

DETAIL C-34
BULKHEAD A

DETAIL C-38
BULKHEAD B

DETAIL D-39
LIMBER HOLE
(applies to all transverse bulkheads)

DETAIL E-35
BULKHEAD E,F,G

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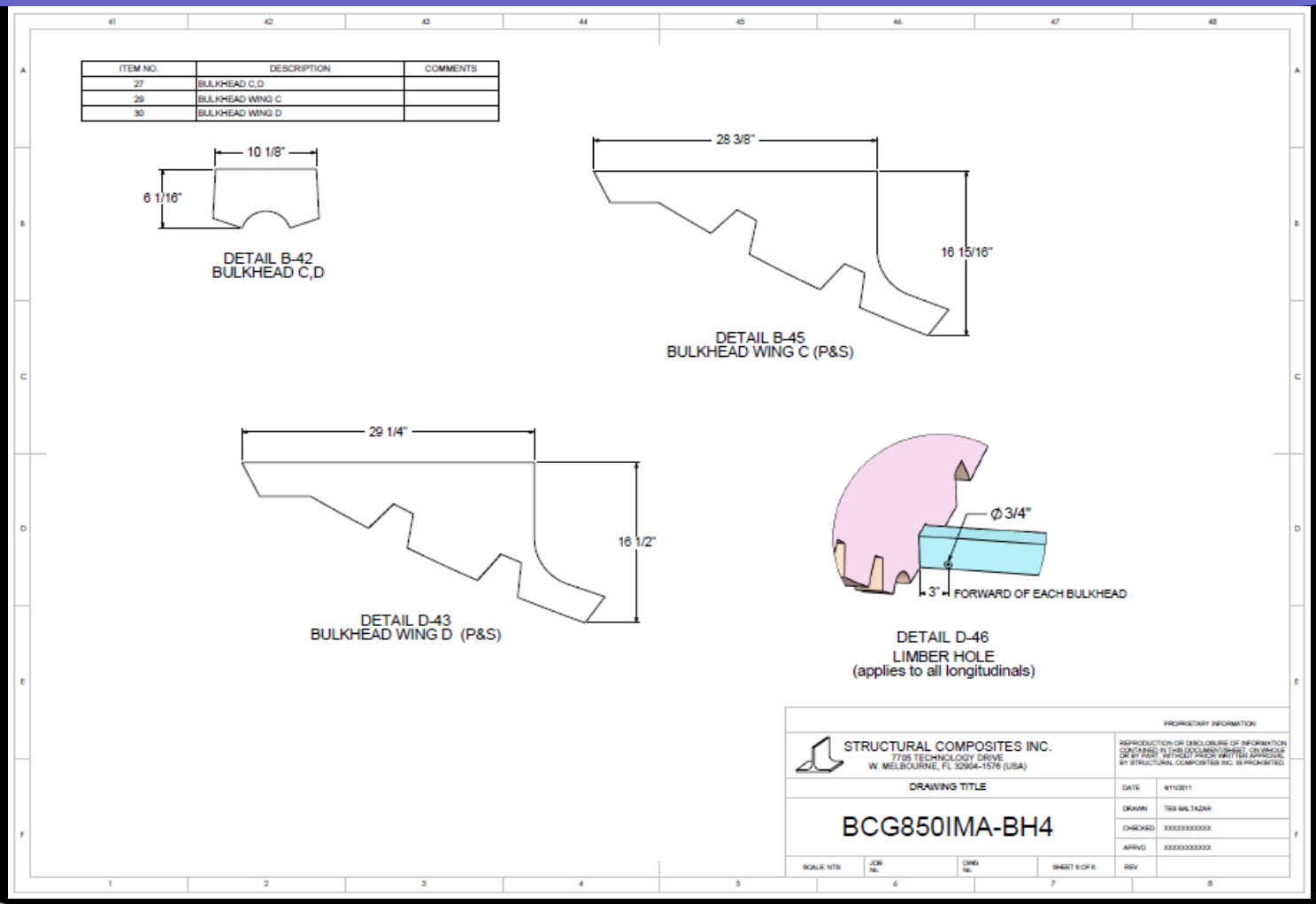
TR4030-68

DATE	4/7/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. | SHEET 5 OF 6

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850A- Hull Drawings



ITEM NO.	DESCRIPTION	COMMENTS
27	BULKHEAD C,D	
29	BULKHEAD WING C	
30	BULKHEAD WING D	

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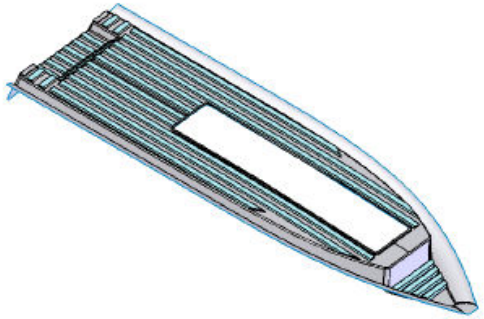
850A- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC KO22-EB8-00 Resin	Alpha Owens Corning	KO22-EB8-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E L7M 3610 0/90 fabric	Vectorply	E L7M 3610	0/90 fabric
5		not used			
6		not used			
7	A/R	E-BXM 2406 +/- 45 fabric	Vectorply	E-BXM 2406	+/-45 fabric
8	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
9	130 LF	TR4010	Compsys	TR4010	
10	10 LF	TR3030X	Compsys	TR3030X	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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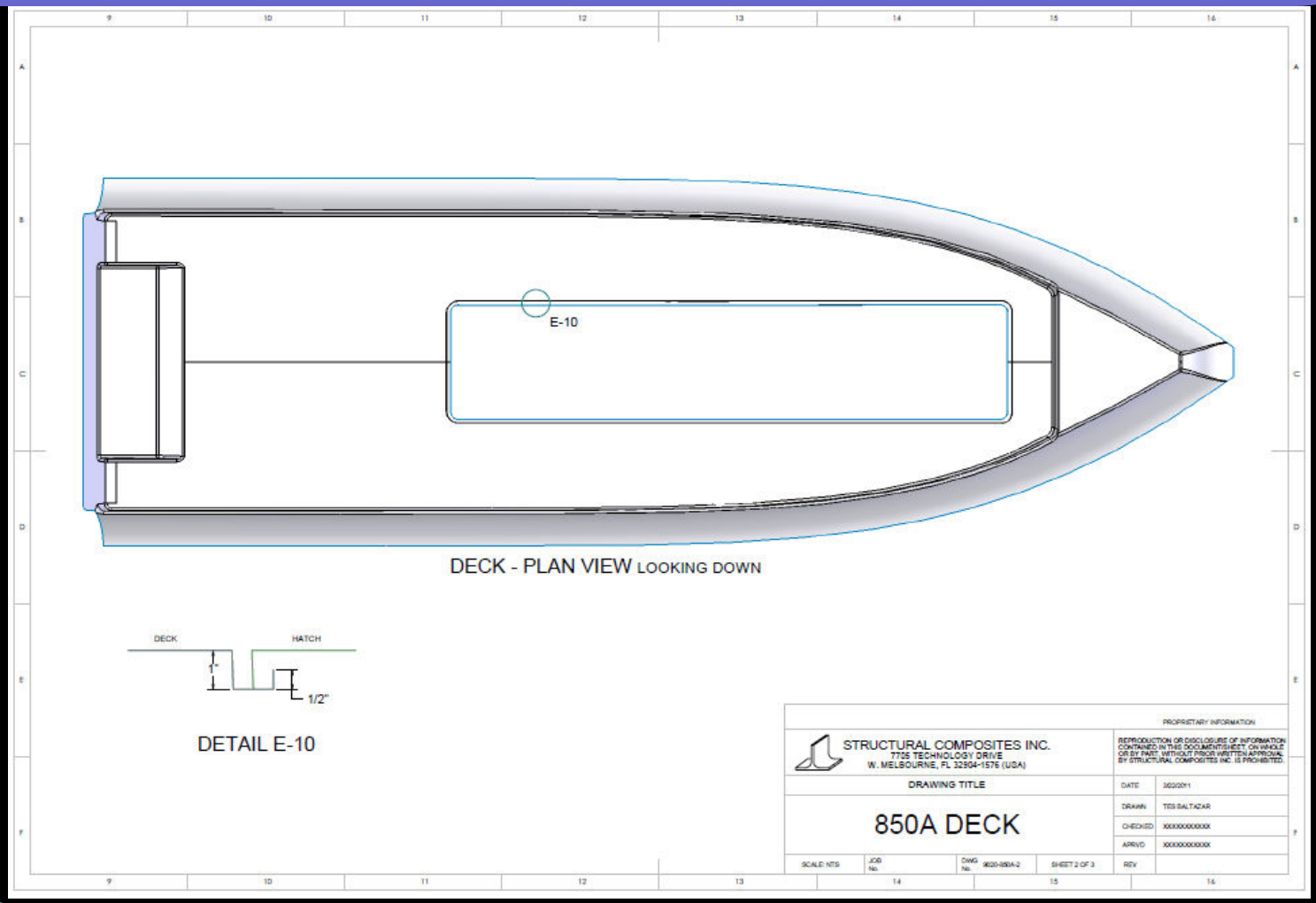
850A DECK

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 9000-850A-2 | SHEET 1 OF 3

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850A- Deck Drawings



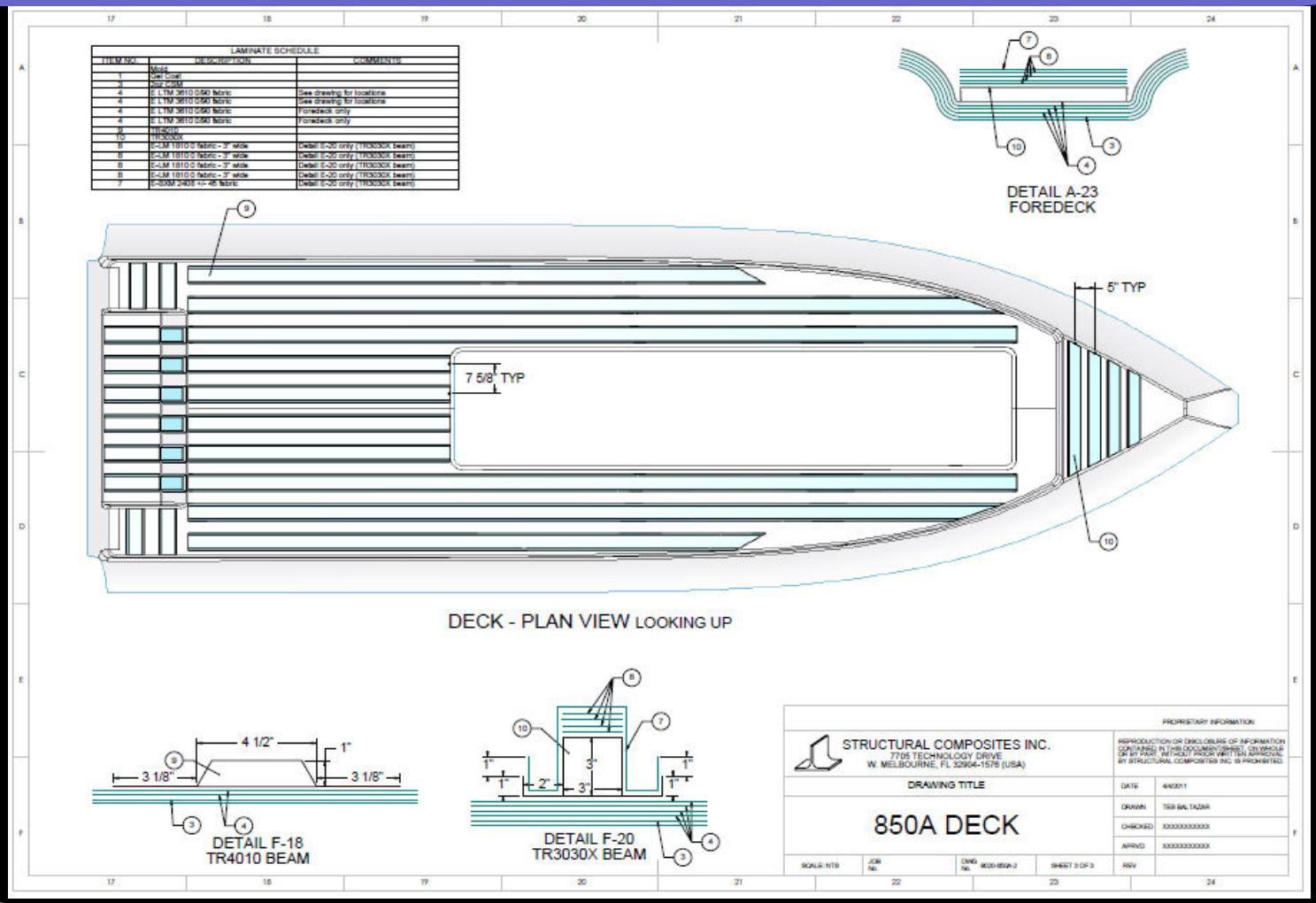
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850A- Deck Drawings



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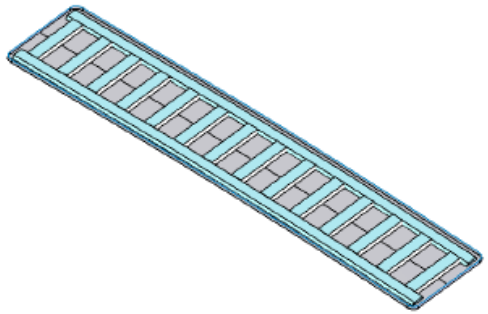
850A- Hatch Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat			
2	A/R	AOC K022-EBB-00 Resin	Alpha Owens Corning	K022-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
8	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
14	50 LF	TR4010	Compsys	TR4010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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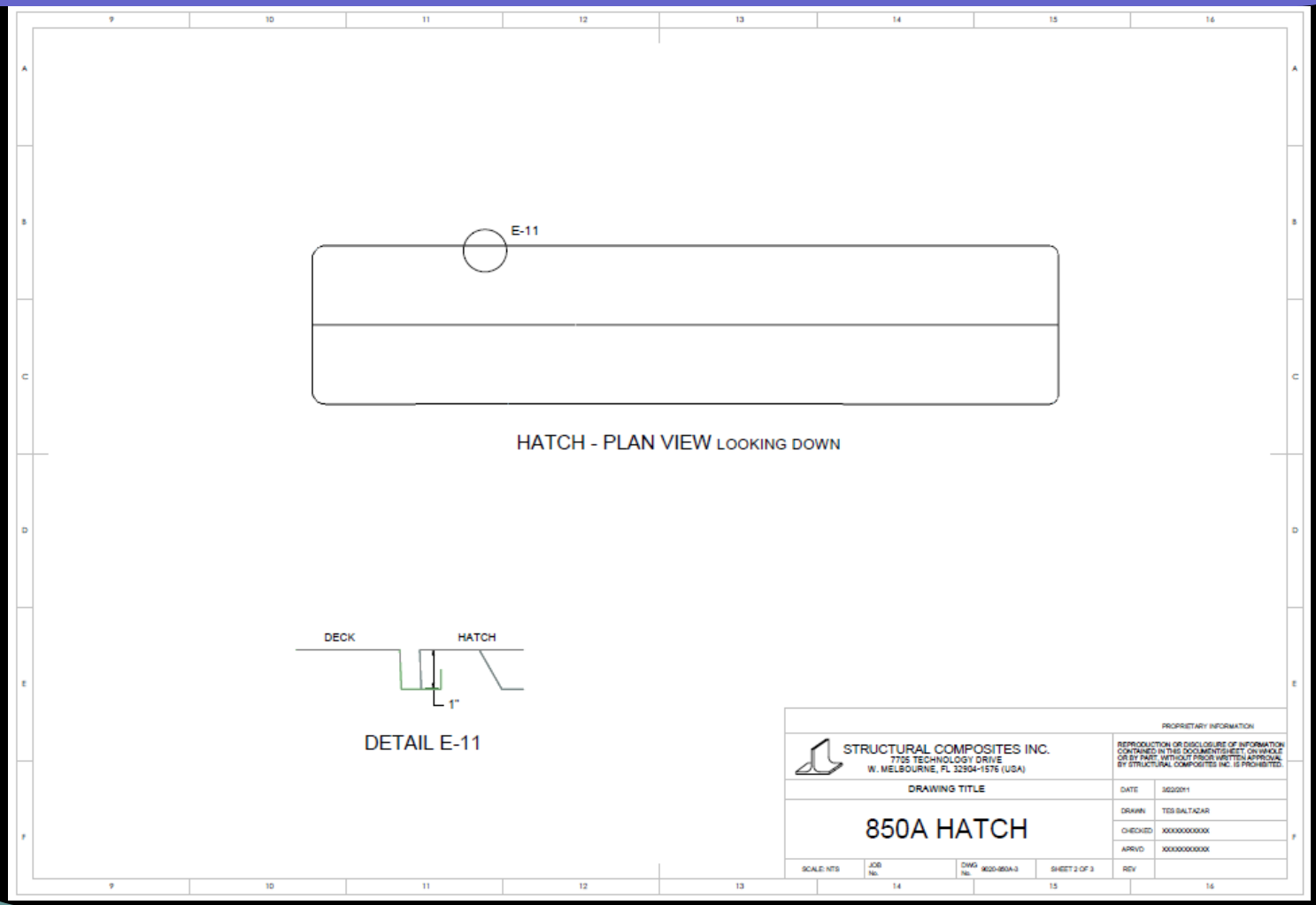
850A HATCH

DATE	4/4/2011
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 8020-850A-0 | SHEET 1 OF 3

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850A- Hatch Drawings



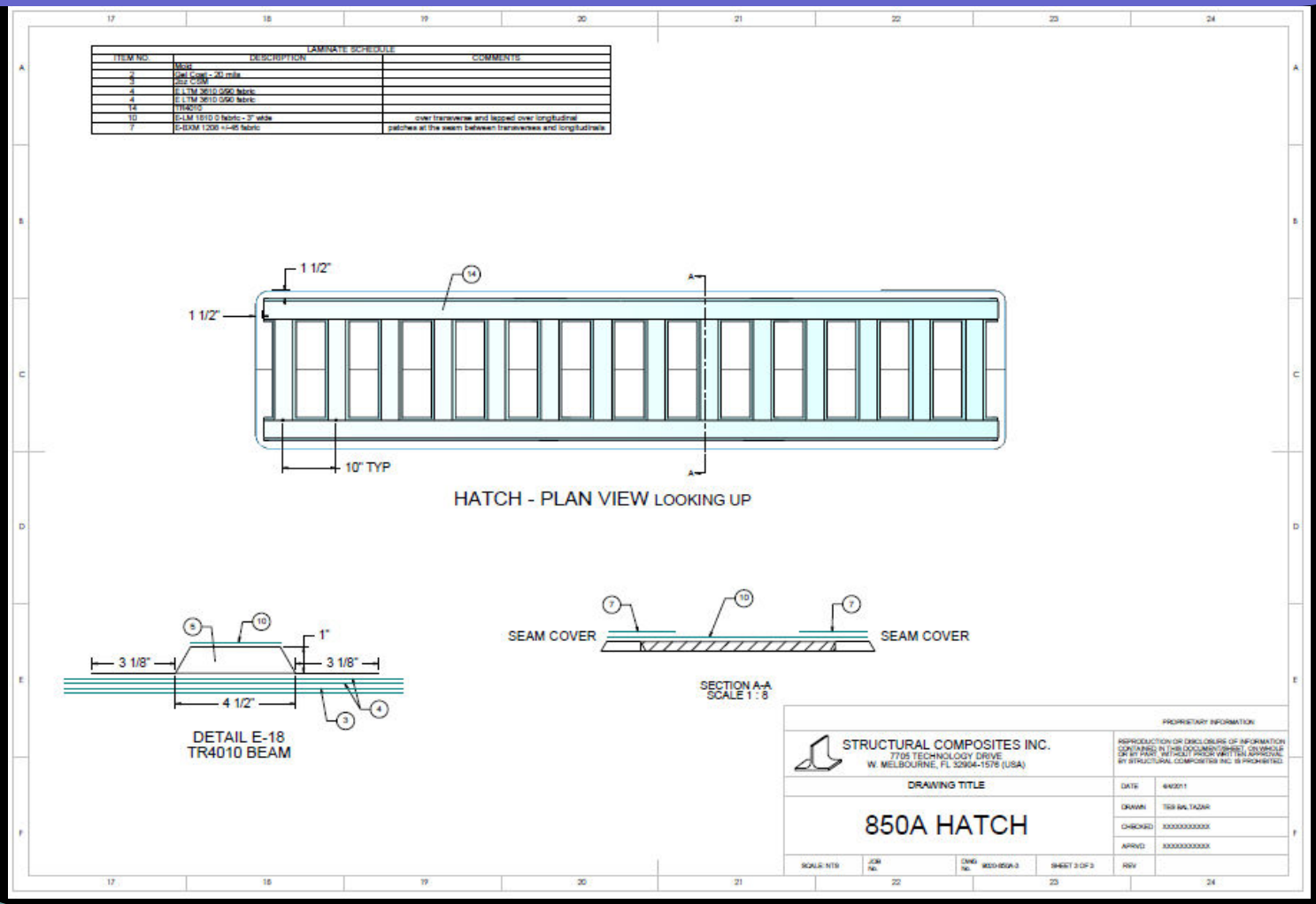
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850A- Hatch Drawings



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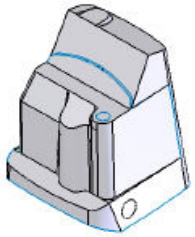
850A- Hardware- Console

BOM

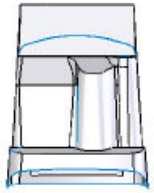
ITEM NO.	QTY	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS

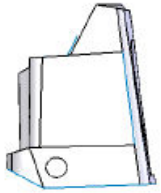
REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED









GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850A CONSOLE

DATE	3/25/2011
DRAWN	TED BALTAZAR
CHECKED	XXXXXXXXXXX
APPVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB NO. | DWG NO. 850-850A-1 | SHEET 1 OF 1

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850A – Laminate Schedule

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 3 x 3610
- Stringers – TR4030X /1810 / 1208 / 3608
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 3610 / 2408 / 1810 / TR4010 / TR3030X
- Deck Framing – Gel Coat / 2oz CSM / 4 x 3610 / TR4010 / TR3030X / 4 x 1810 / 2408
- Transom – Gel Coat / 2oz CSM / 2 x 3610 / 3oz CSM / 26lb Density Core / 3610

850A- Complete FEA Analysis











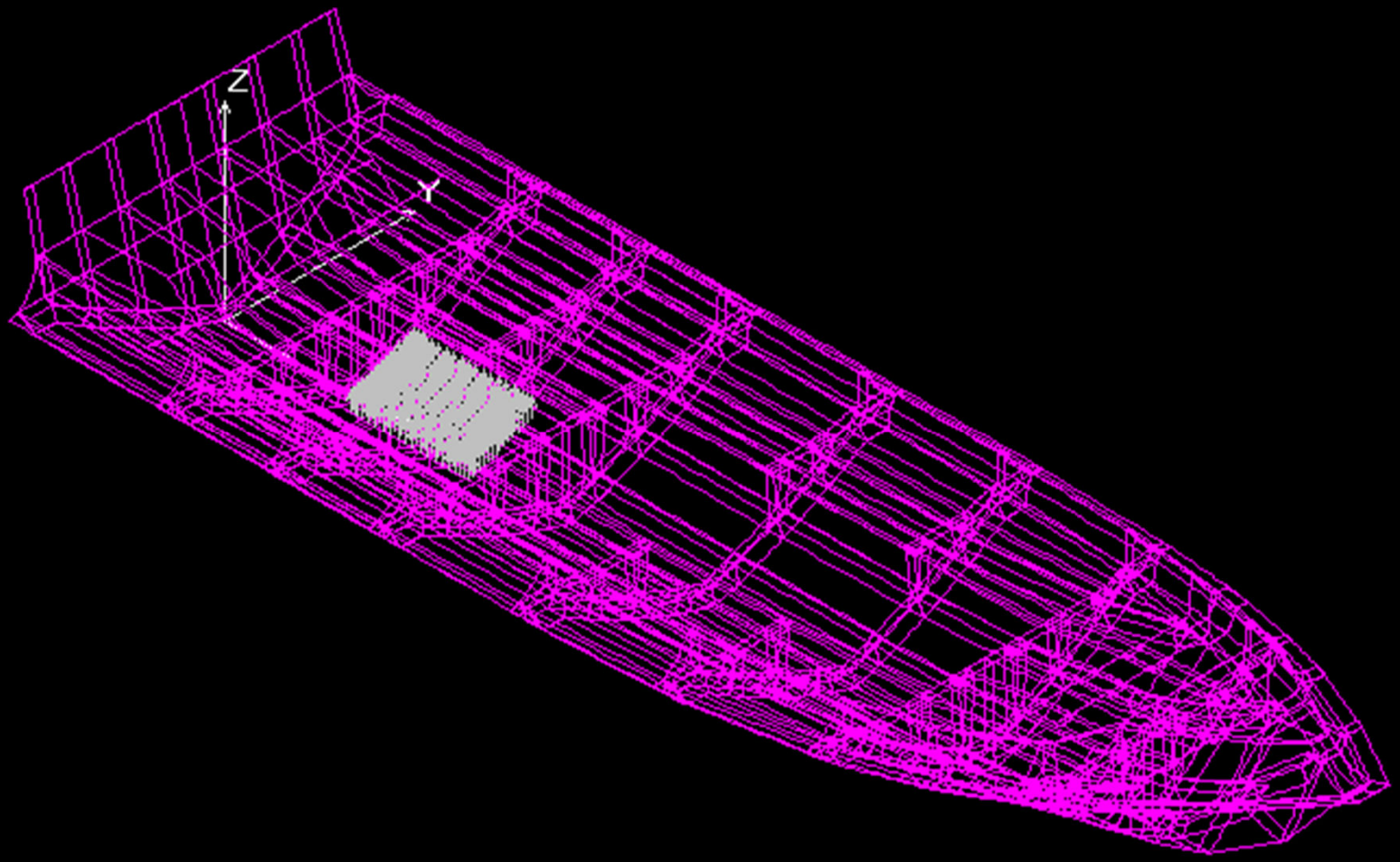
850A- FEA Analysis: Small Area Slamming (SAS)



Small Area Pressure Load

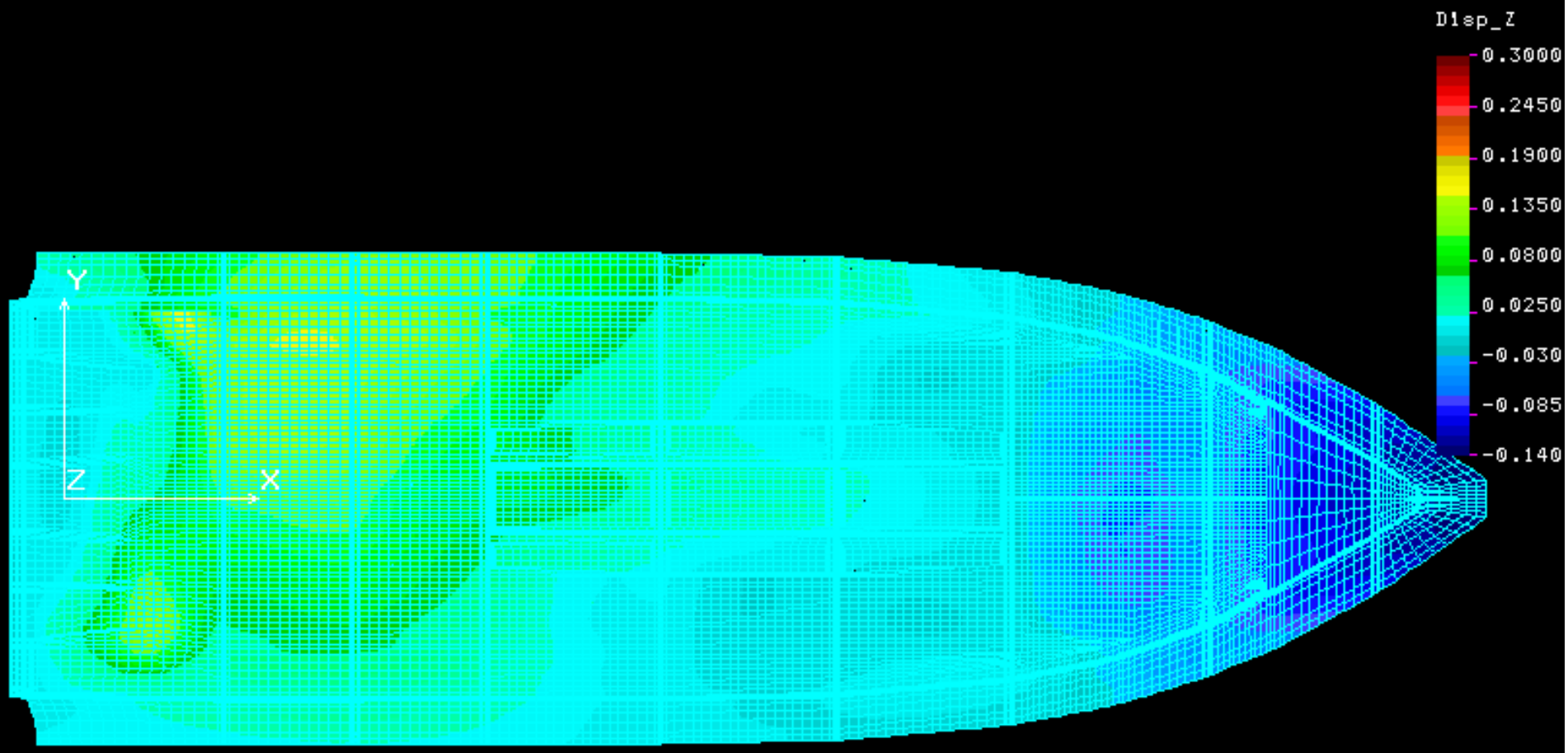
- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

LC1- AMI-10 psi Pressure Load



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LC1- AMI- Z Displacement- Deck



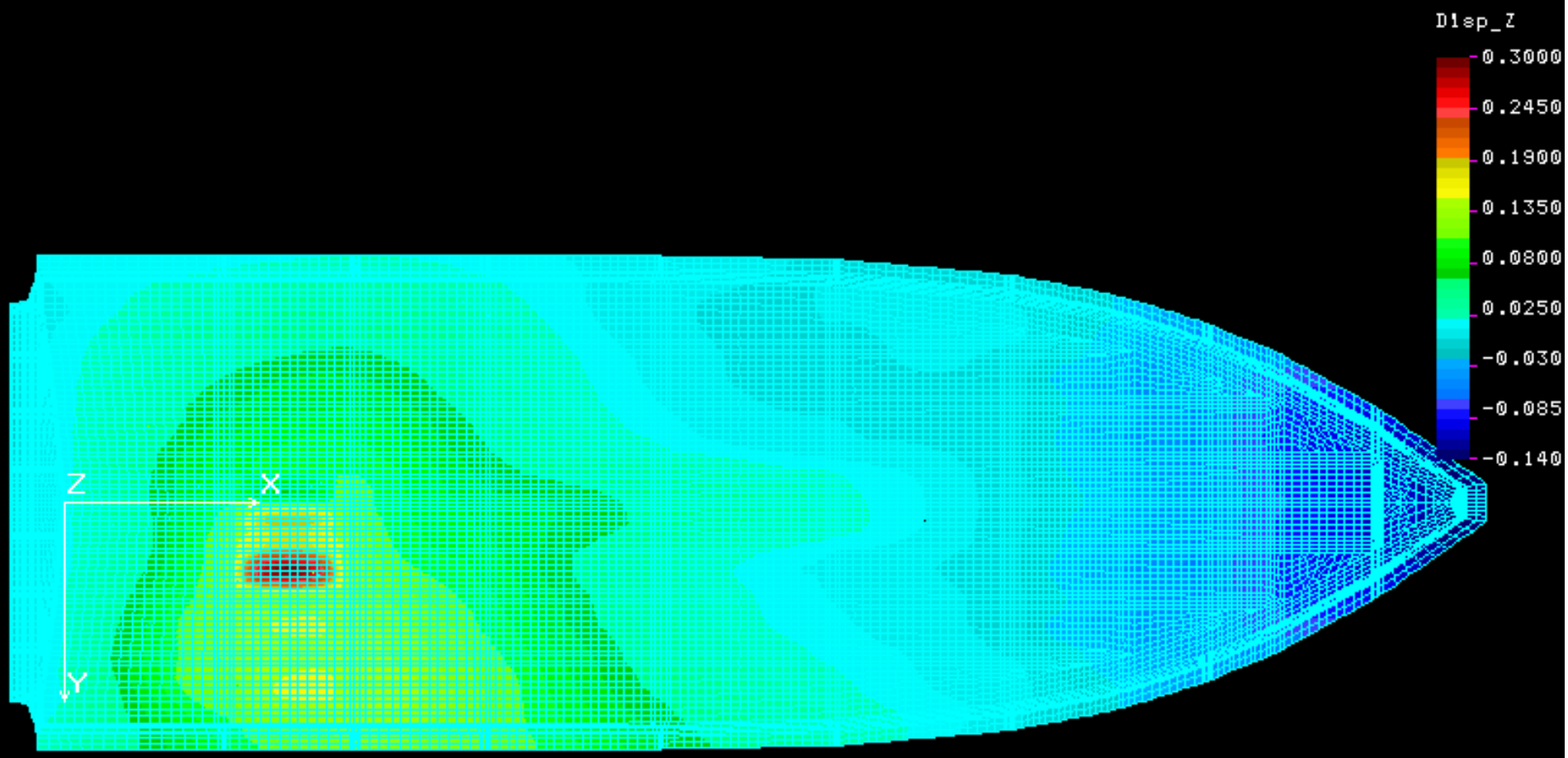
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LC1- AMI- Z Displacement- Hull



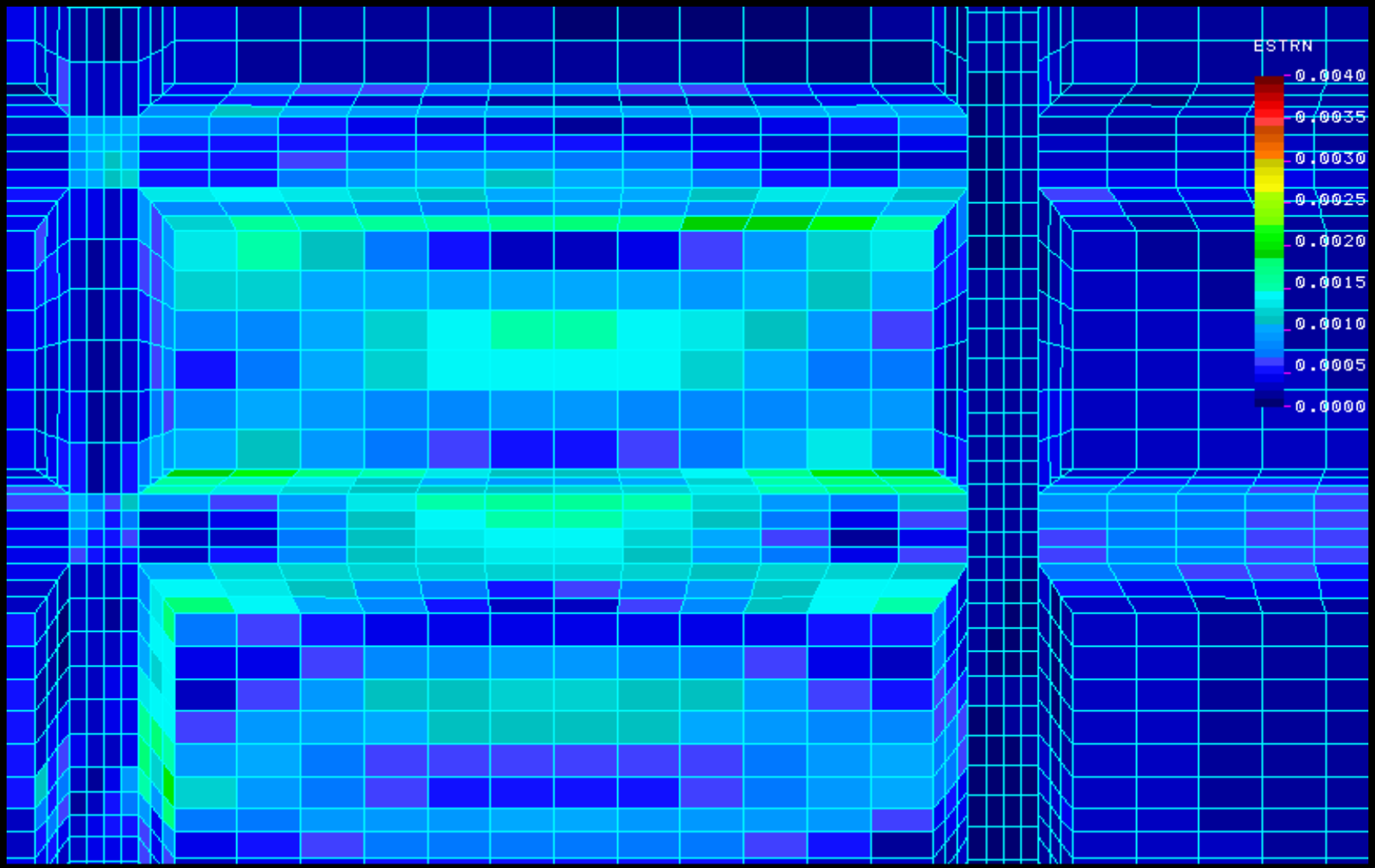
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LC1- AMI- Strain



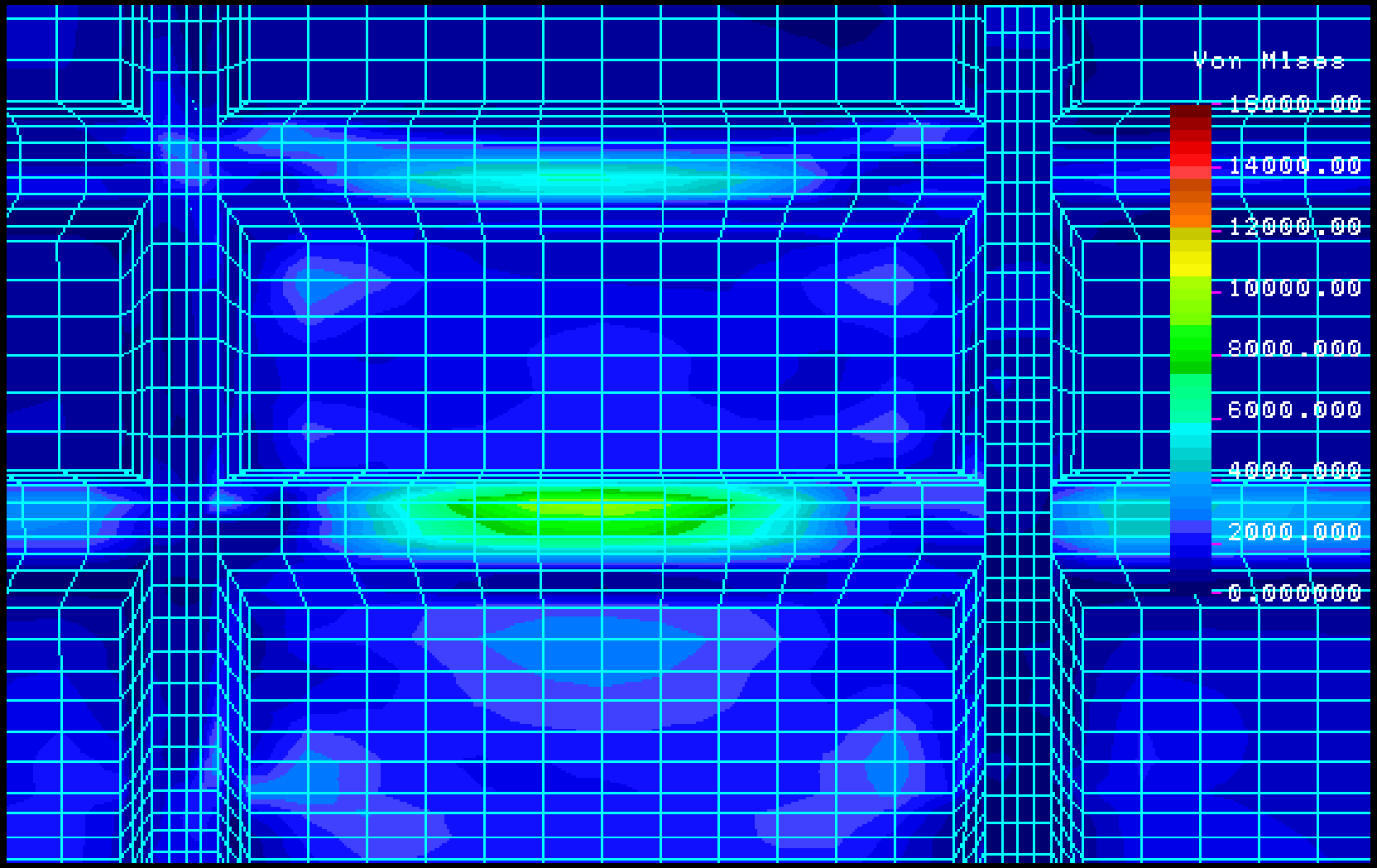
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LC1- AMI- Framing Stress



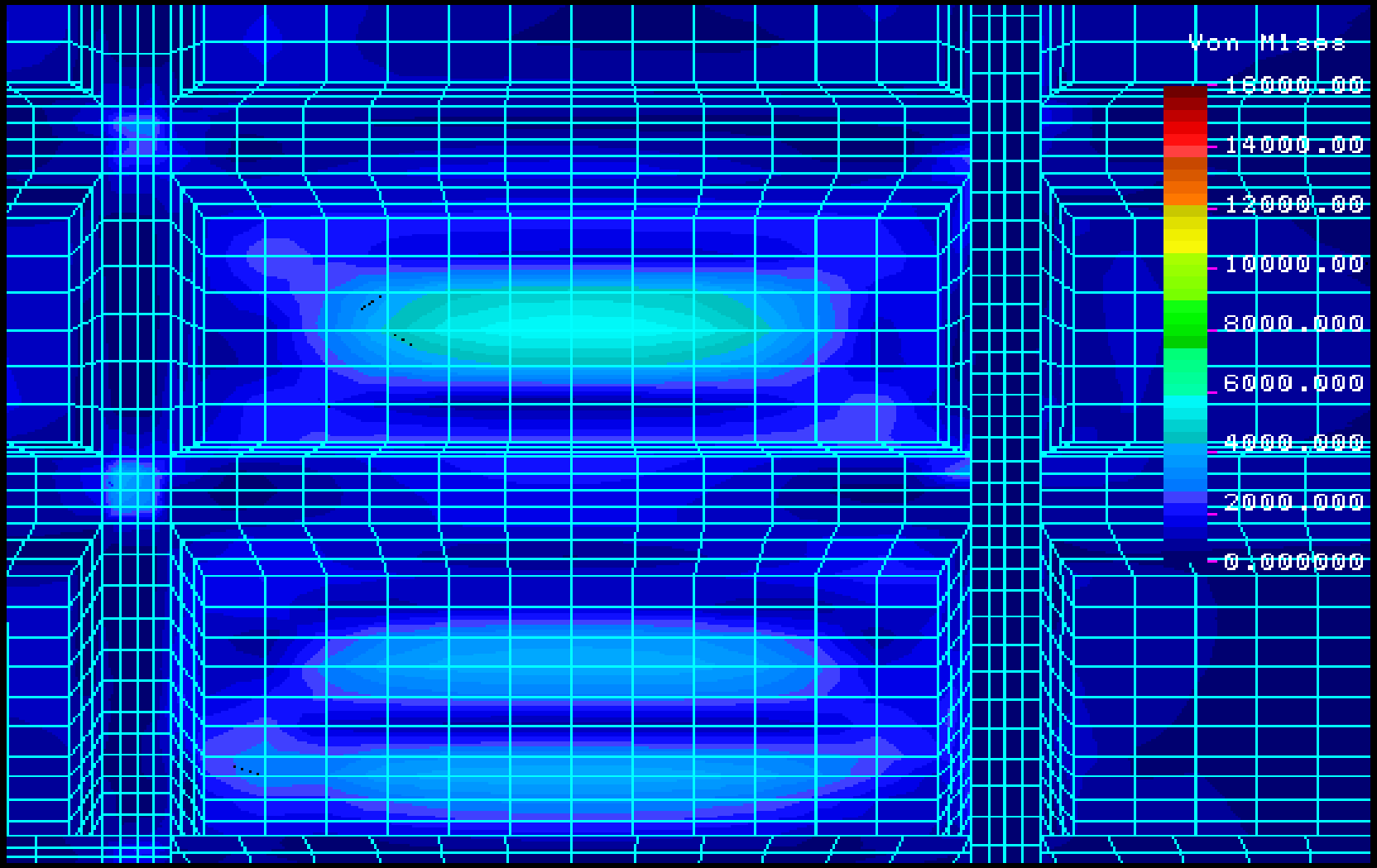
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LC1- Hull Shell Stress



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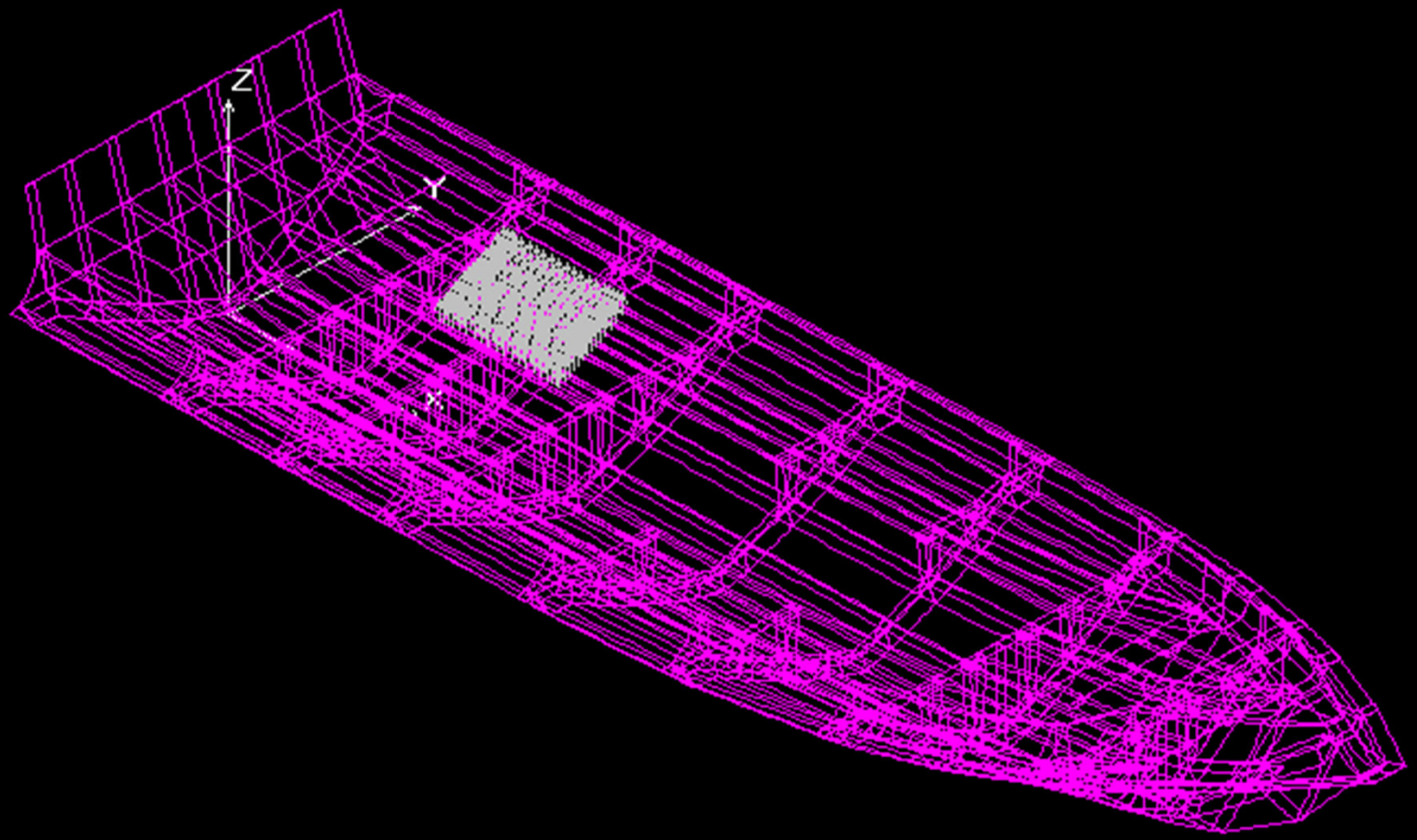
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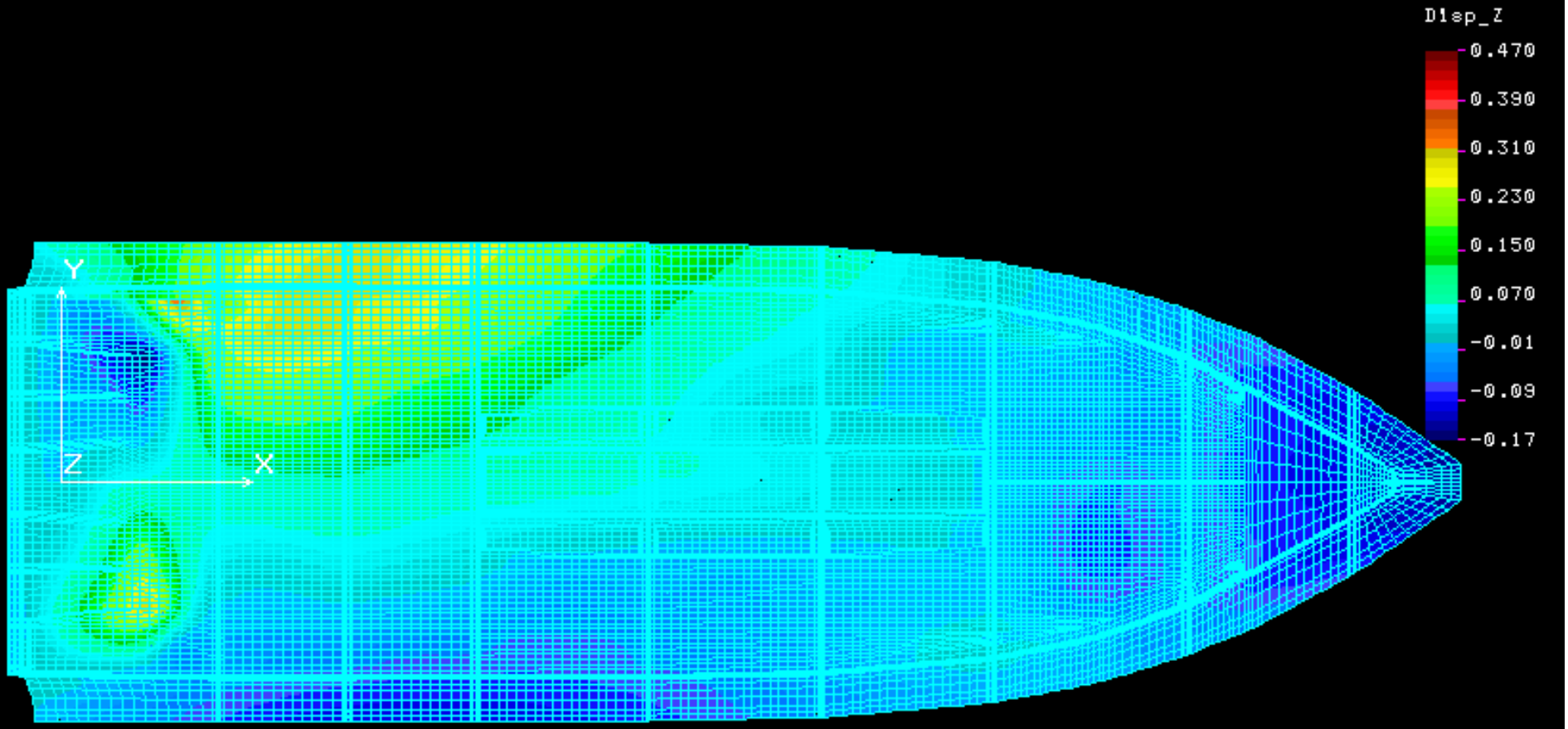
LC1- AMI- Summary

- Deck range of deflection 0.30 in.
- Hull range of deflection 0.44 in.
- Local panel deflection 0.165 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 9,000 psi
- Maximum hull shell stress 5,000 psi

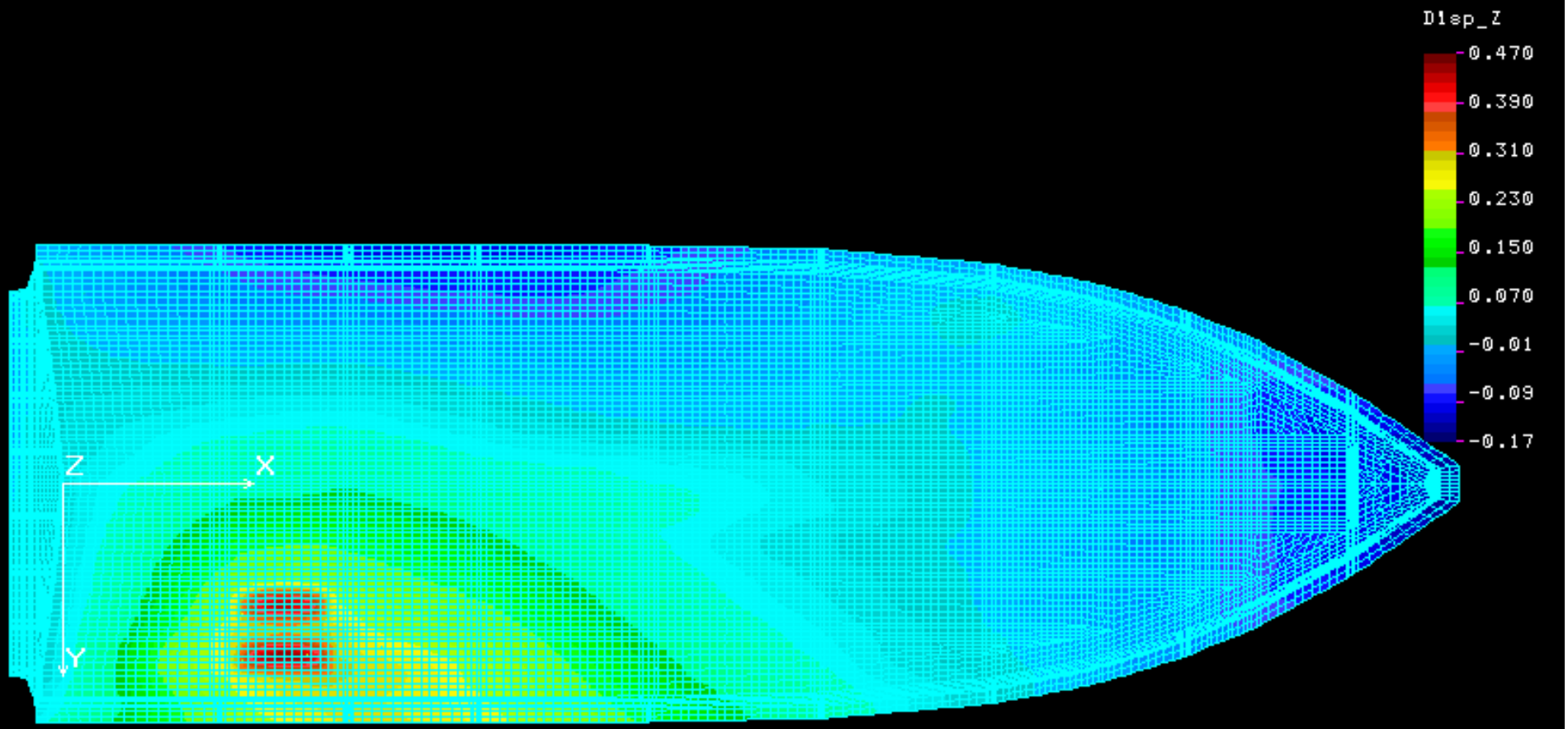
LC2- AMO-10 psi Pressure Load



LC2- AMO- Z Displacement- Deck

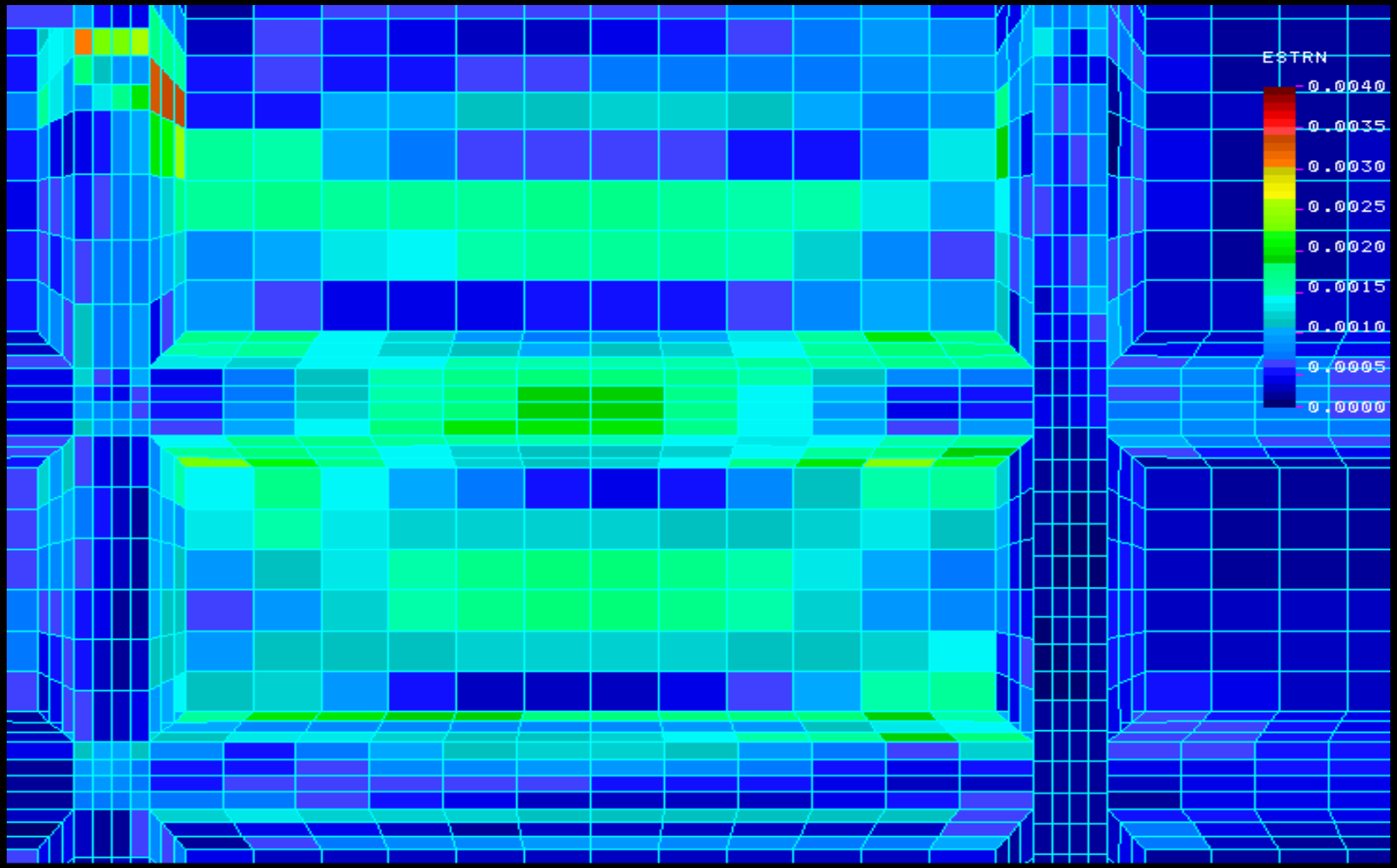


LC2- AMO- Z Displacement- Hull

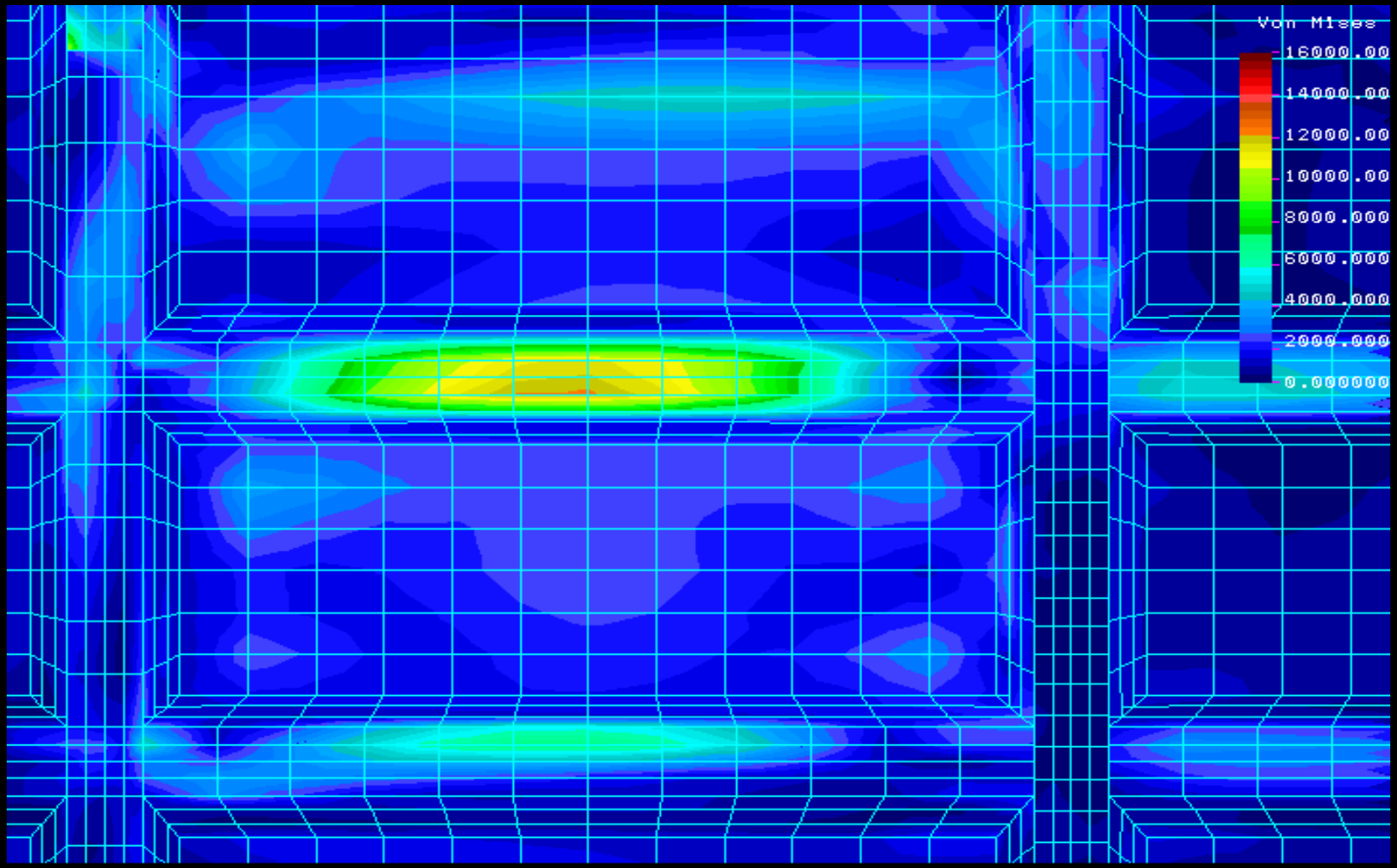


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LC2- AMO- Strain



LC2- AMO- Framing Stress



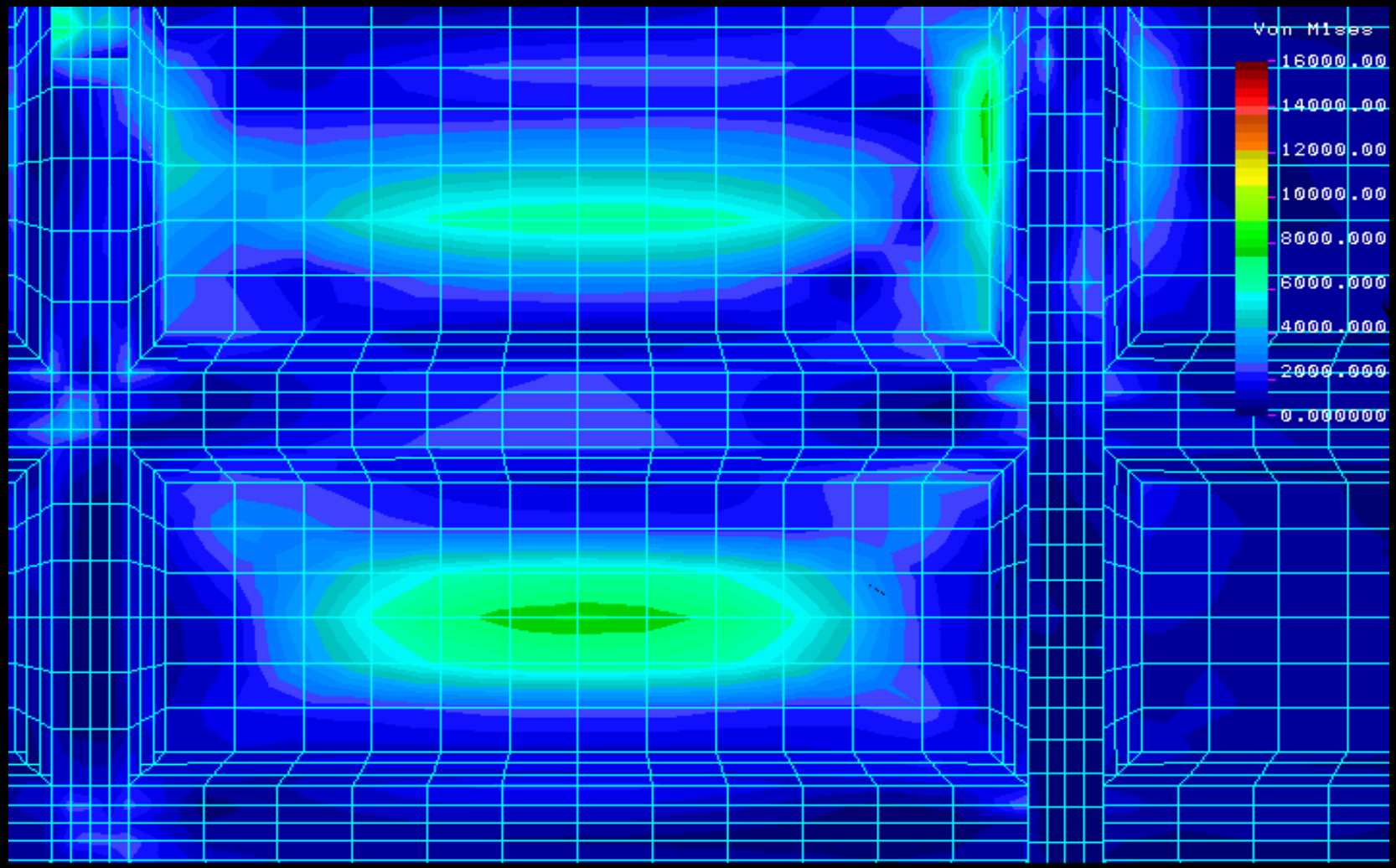
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LC2- AMO- Hull Shell Stress



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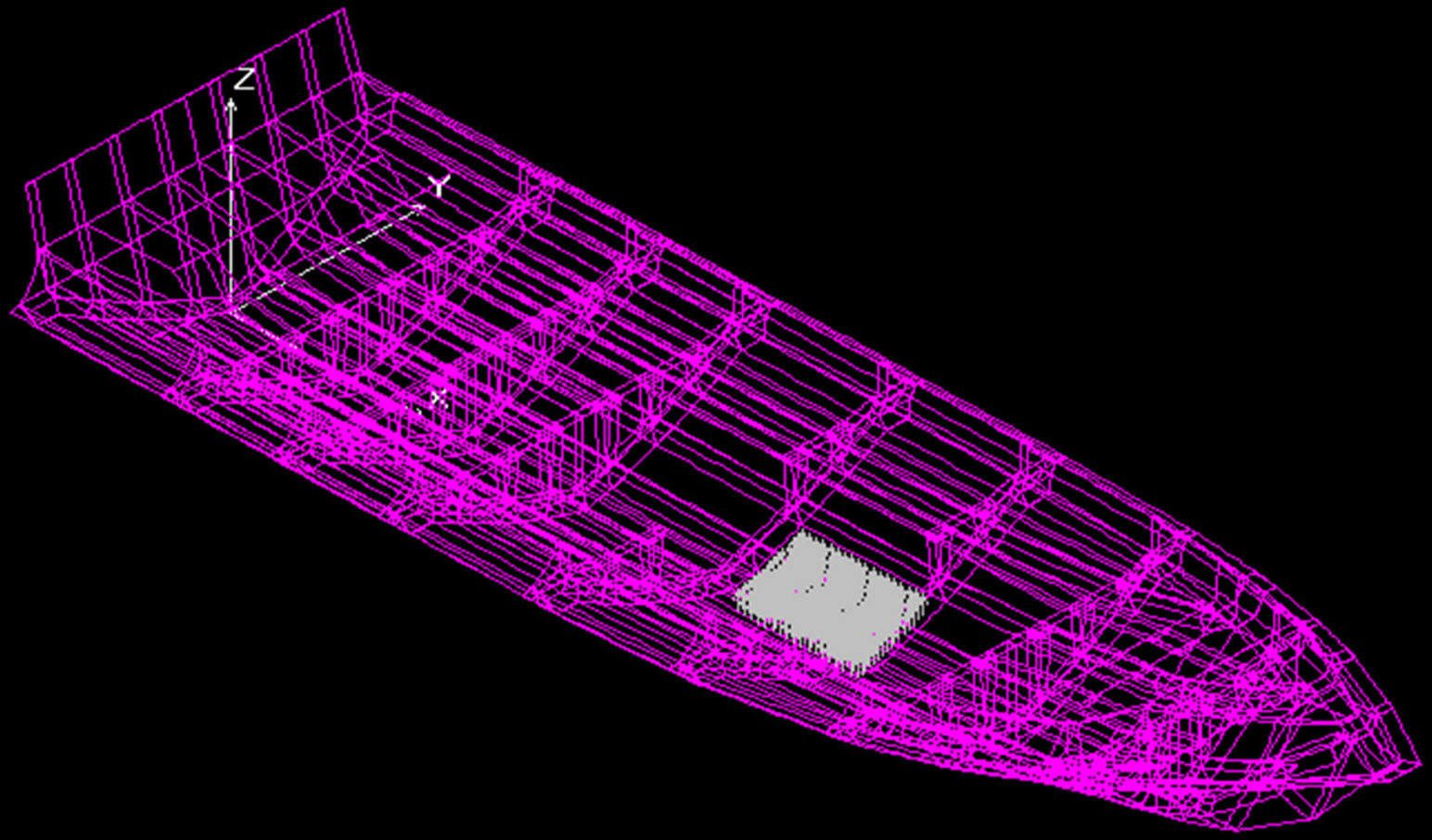
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LC2- AMO- Summary

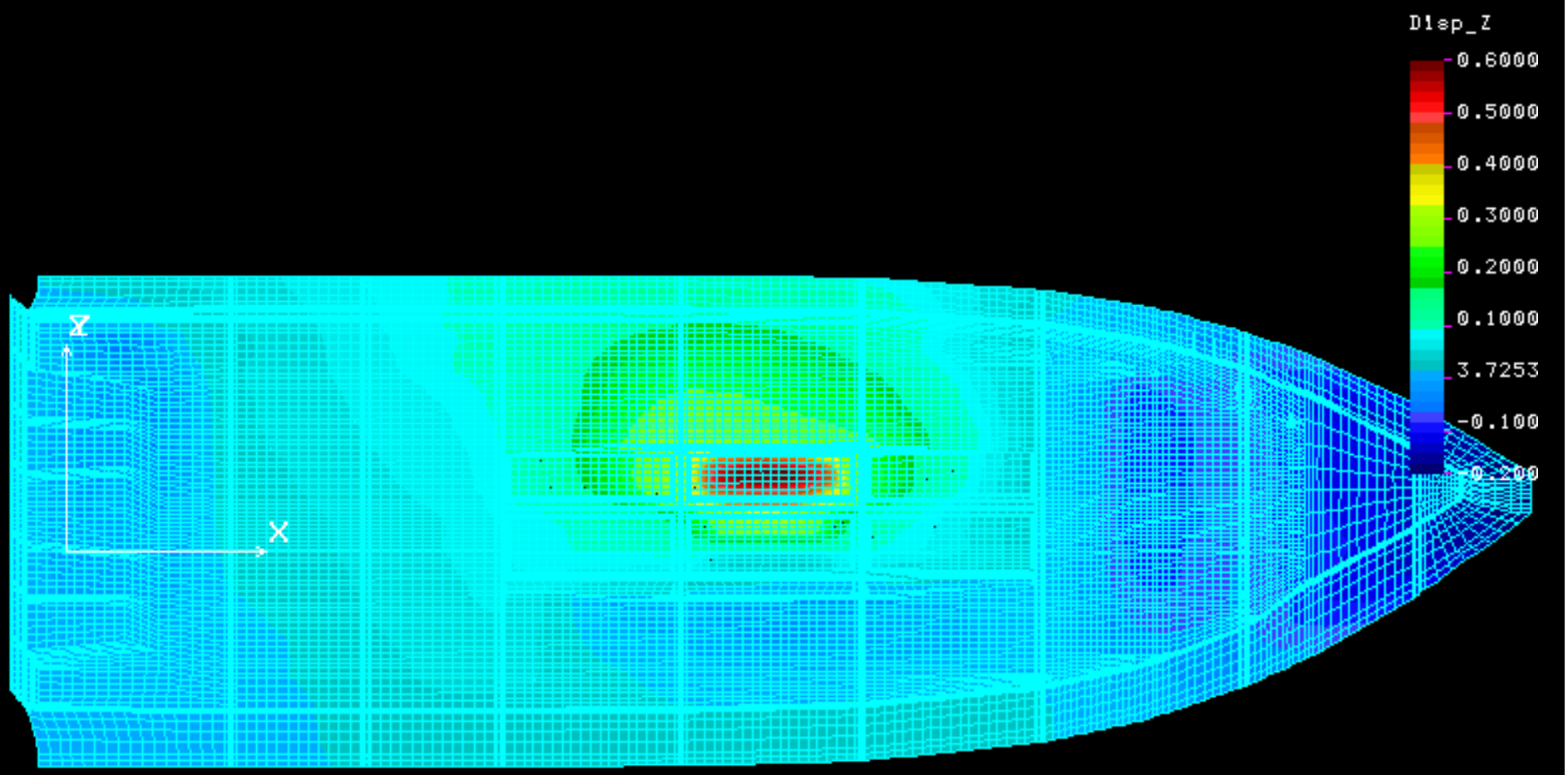
- Deck range of deflection 0.56 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.17 in.
- Maximum strain 0.002 in/in
- Maximum framing stress 10,500 psi
- Maximum hull shell stress 7,000 psi

LC3- FI-10 psi Pressure Load



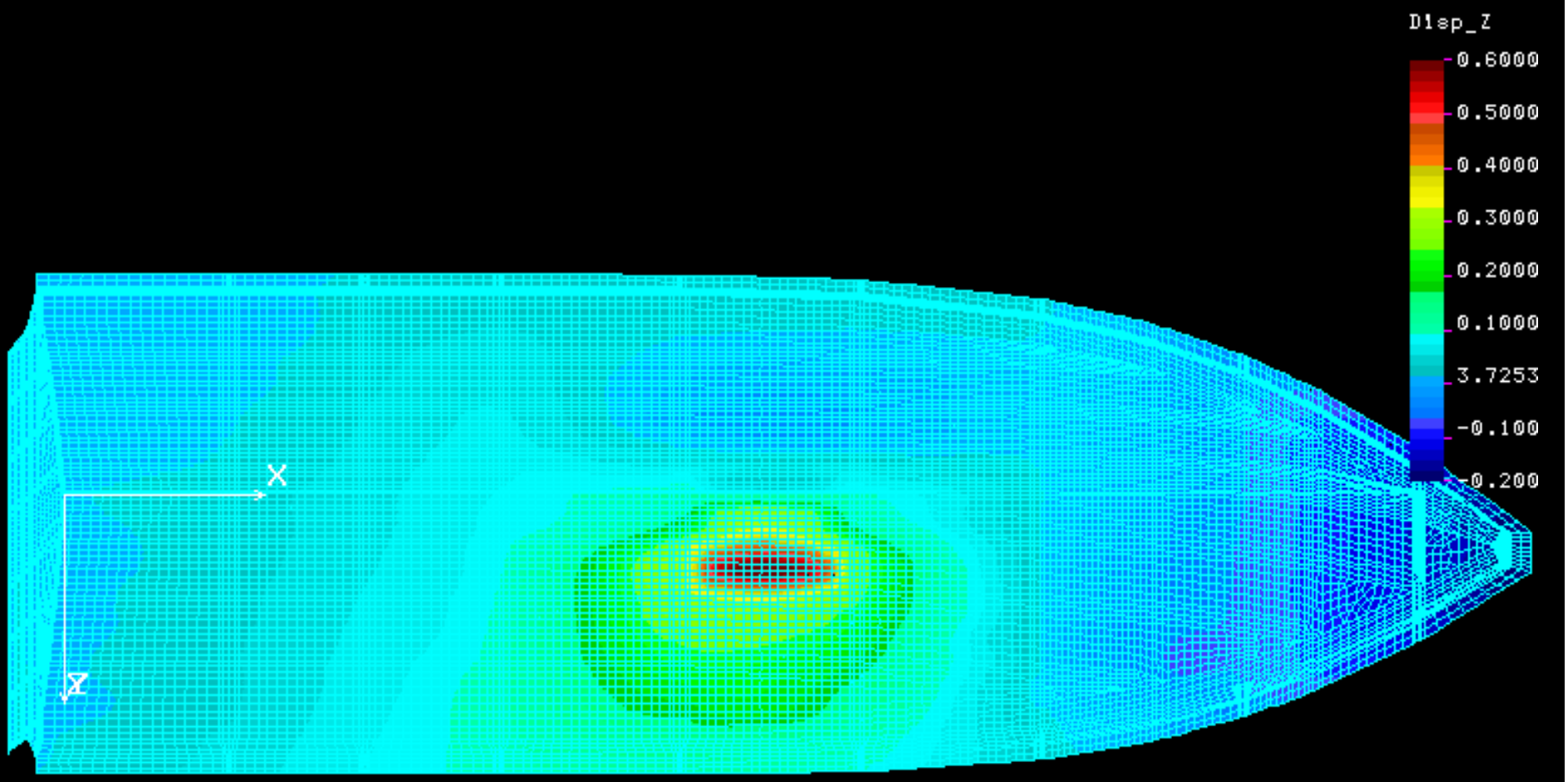
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LC3- FI- Z Displacement - Deck



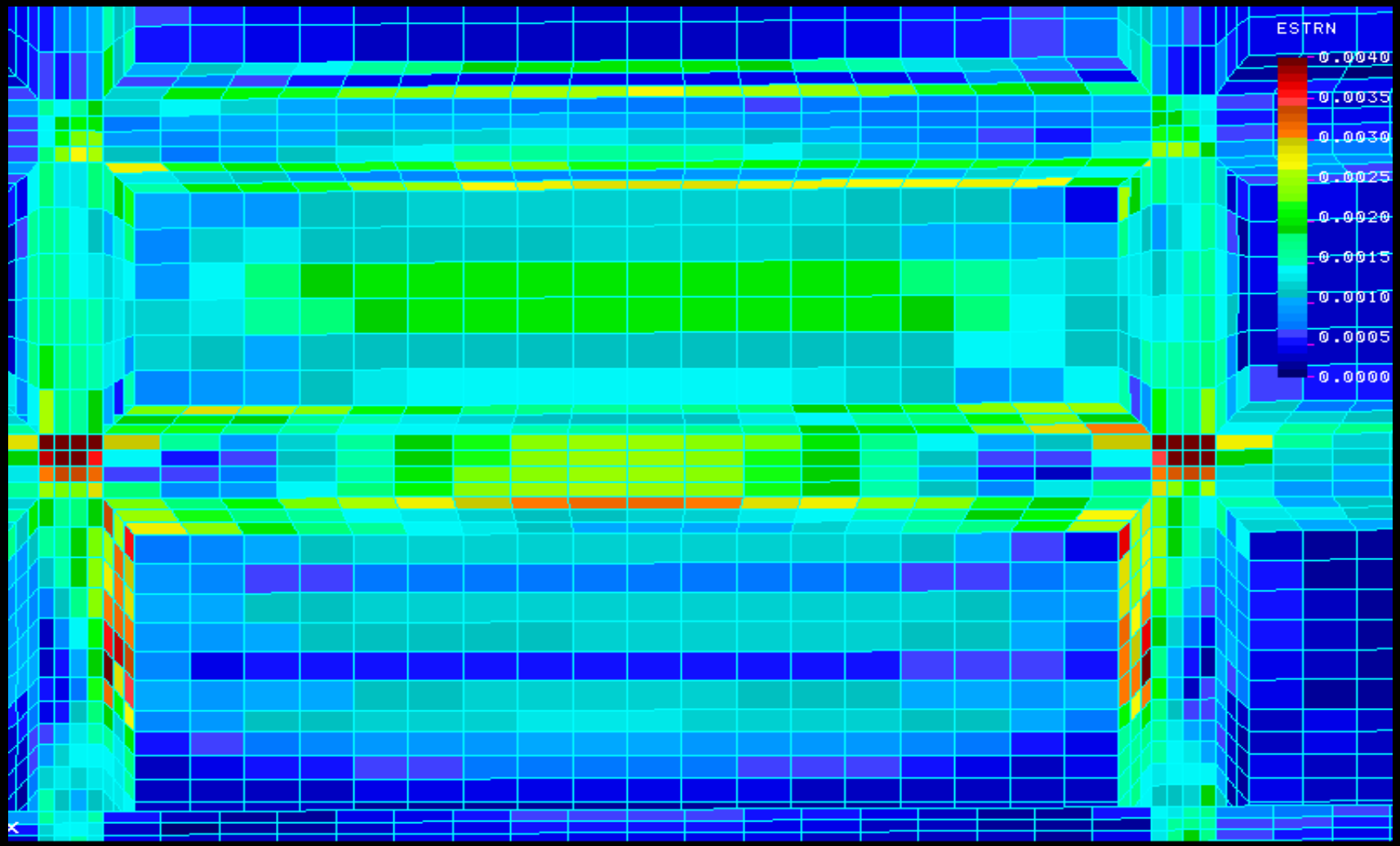
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LC3- FI- Z Displacement - Hull



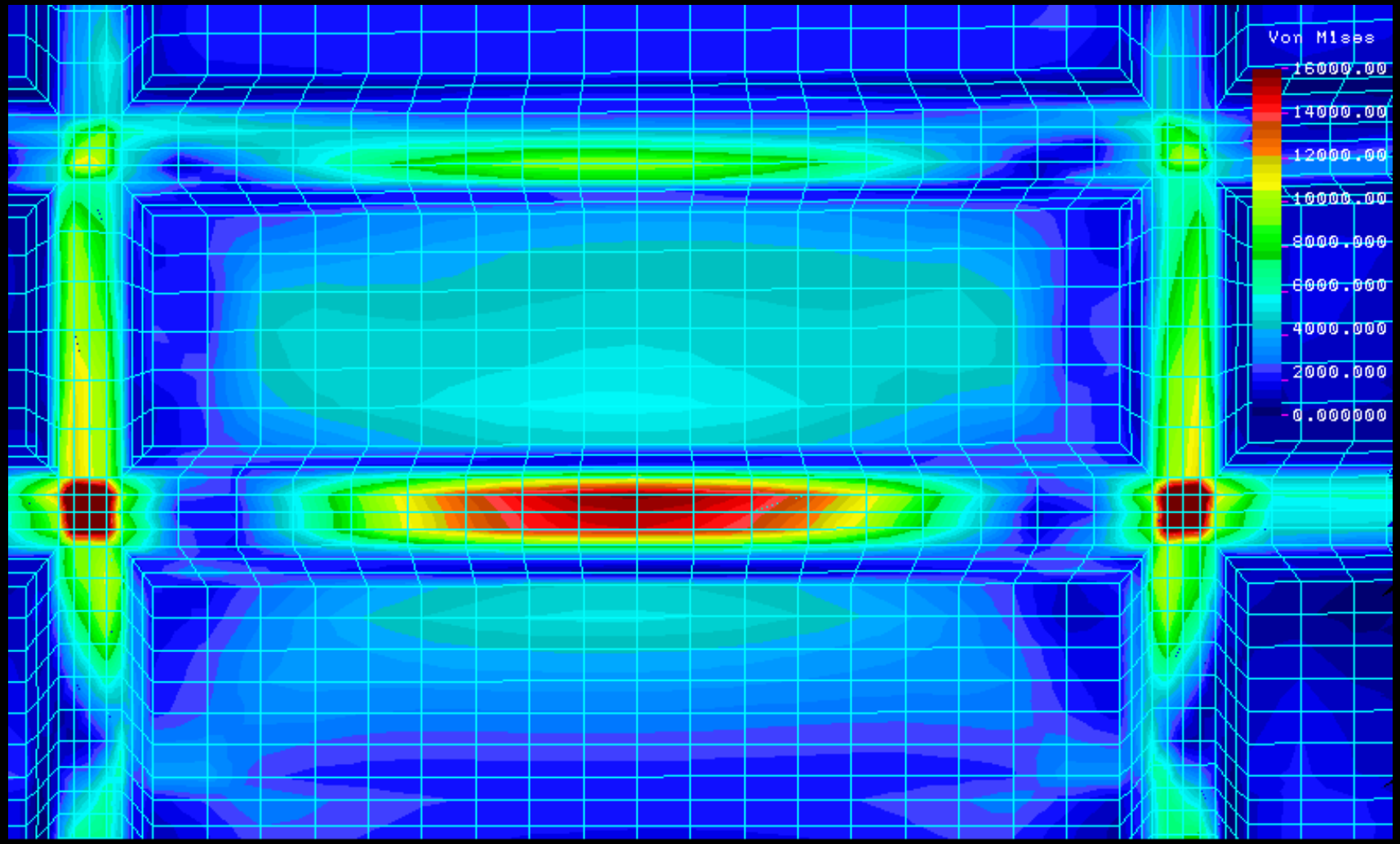
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LC3- FI- Strain



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LC3- FI- Framing Stress



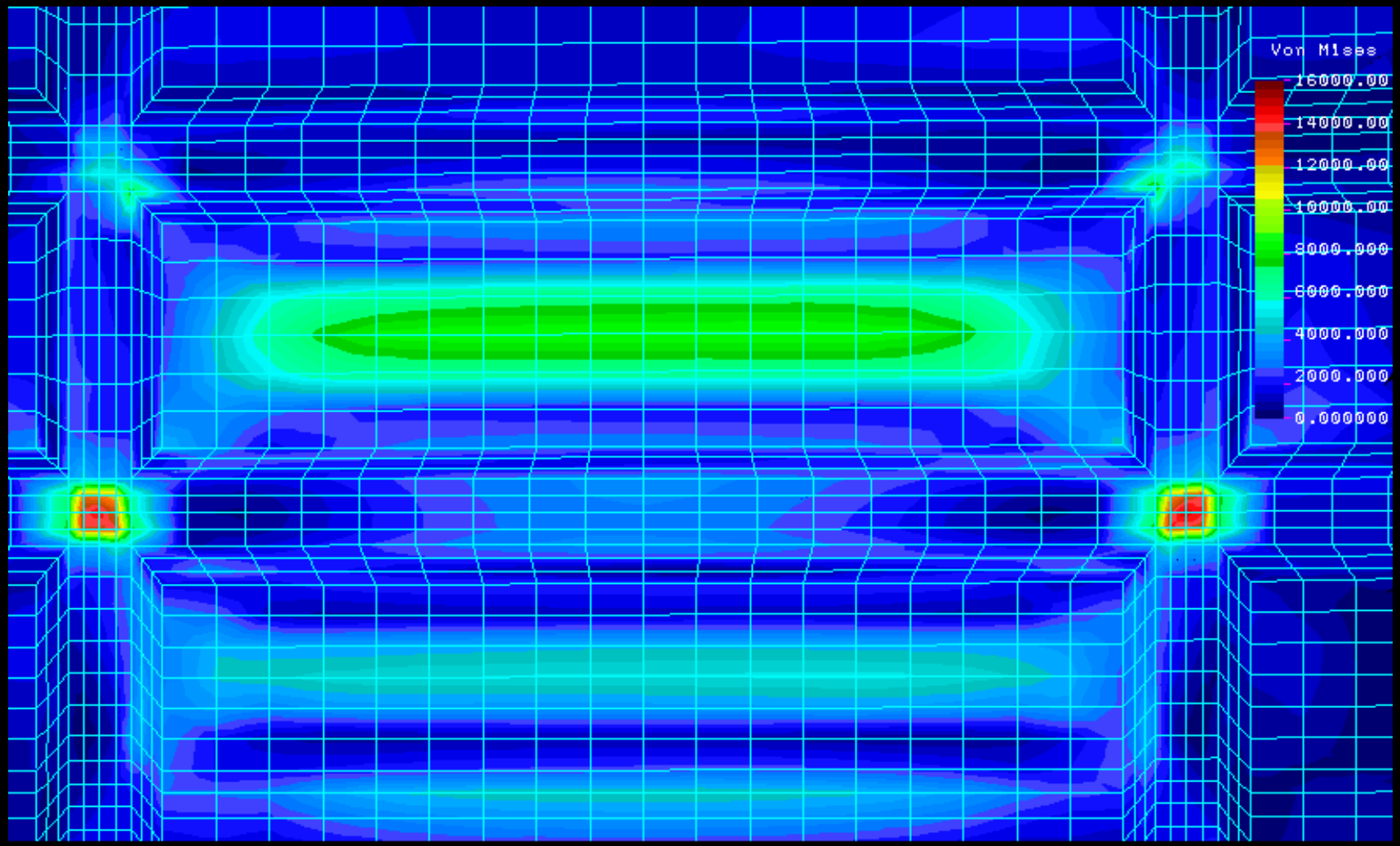
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LC3- FI- Hull Shell Stress



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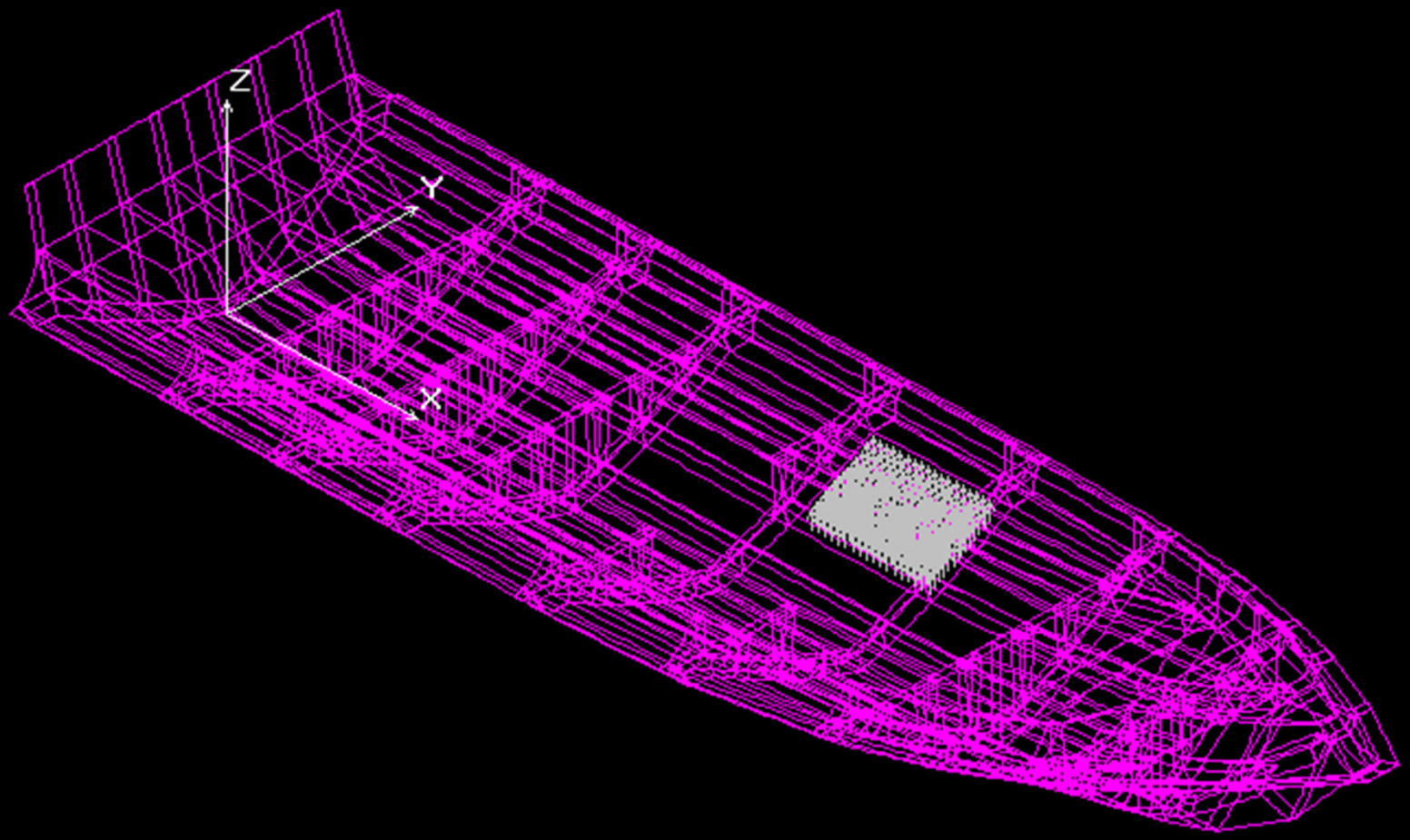
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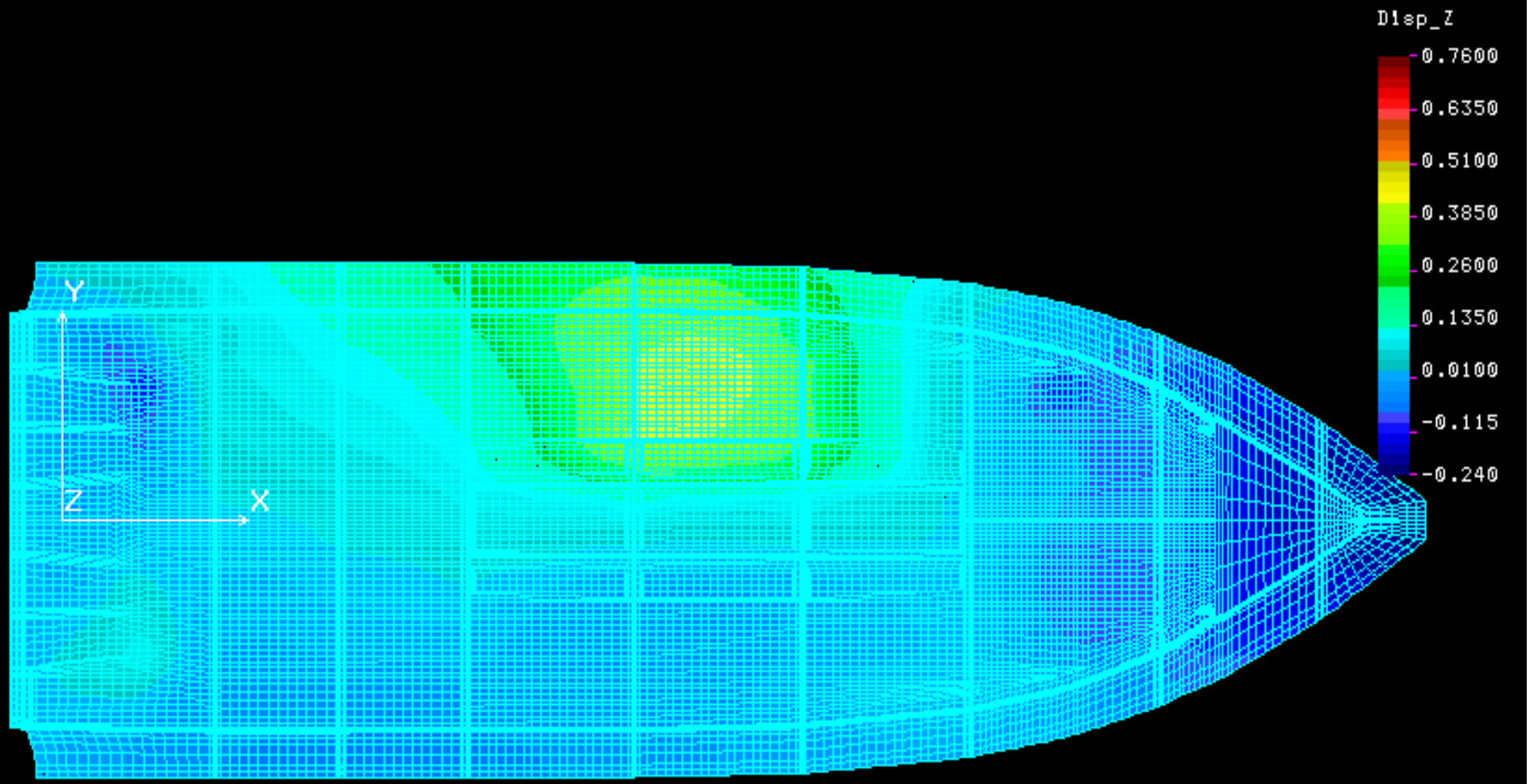
LC3- FI- Summary

- Deck range of deflection 0.8 in.
- Hull range of deflection 0.8 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC4- FO-10 psi Pressure Load

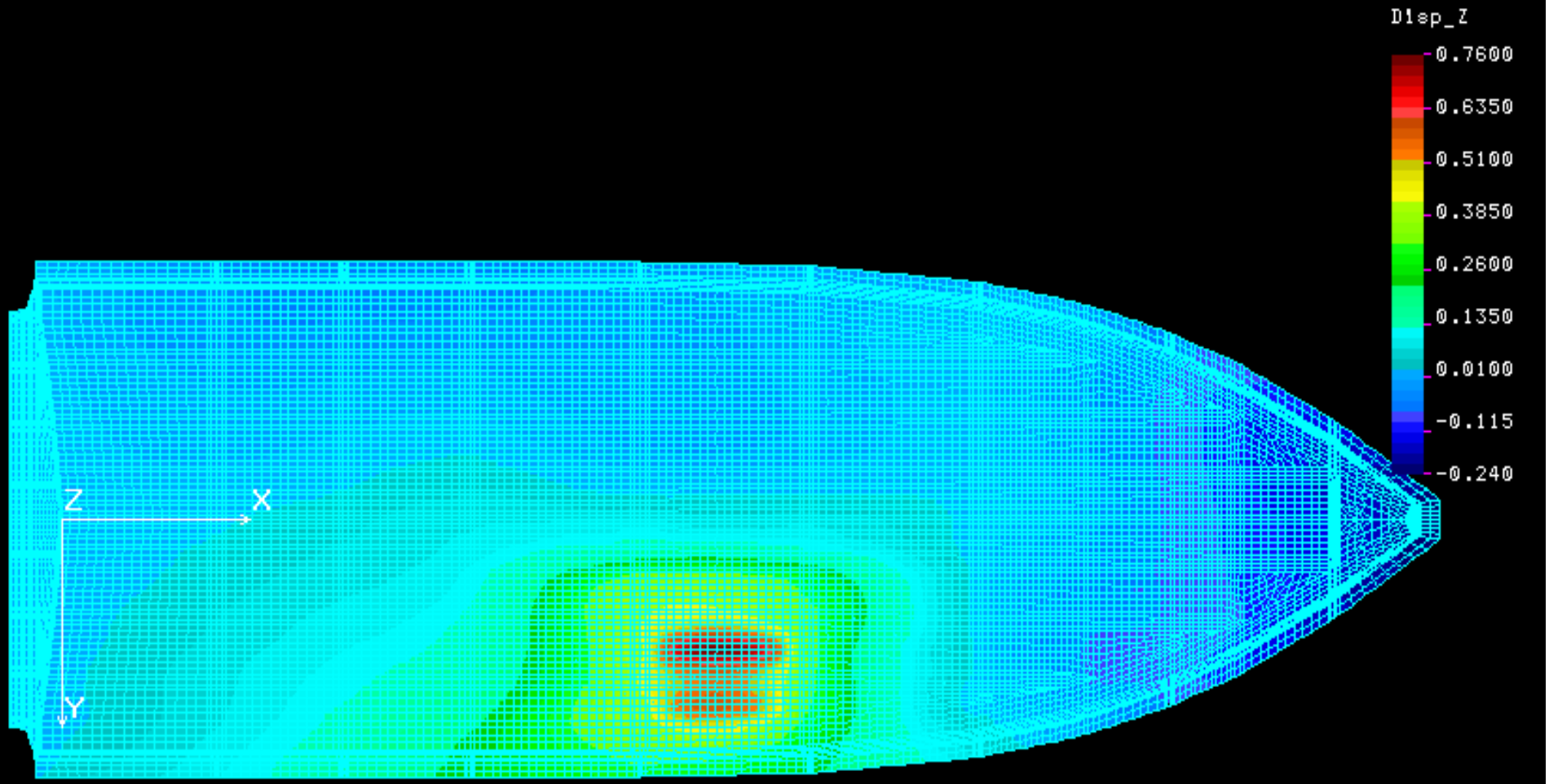


LC4- FO- Z Displacement- Deck



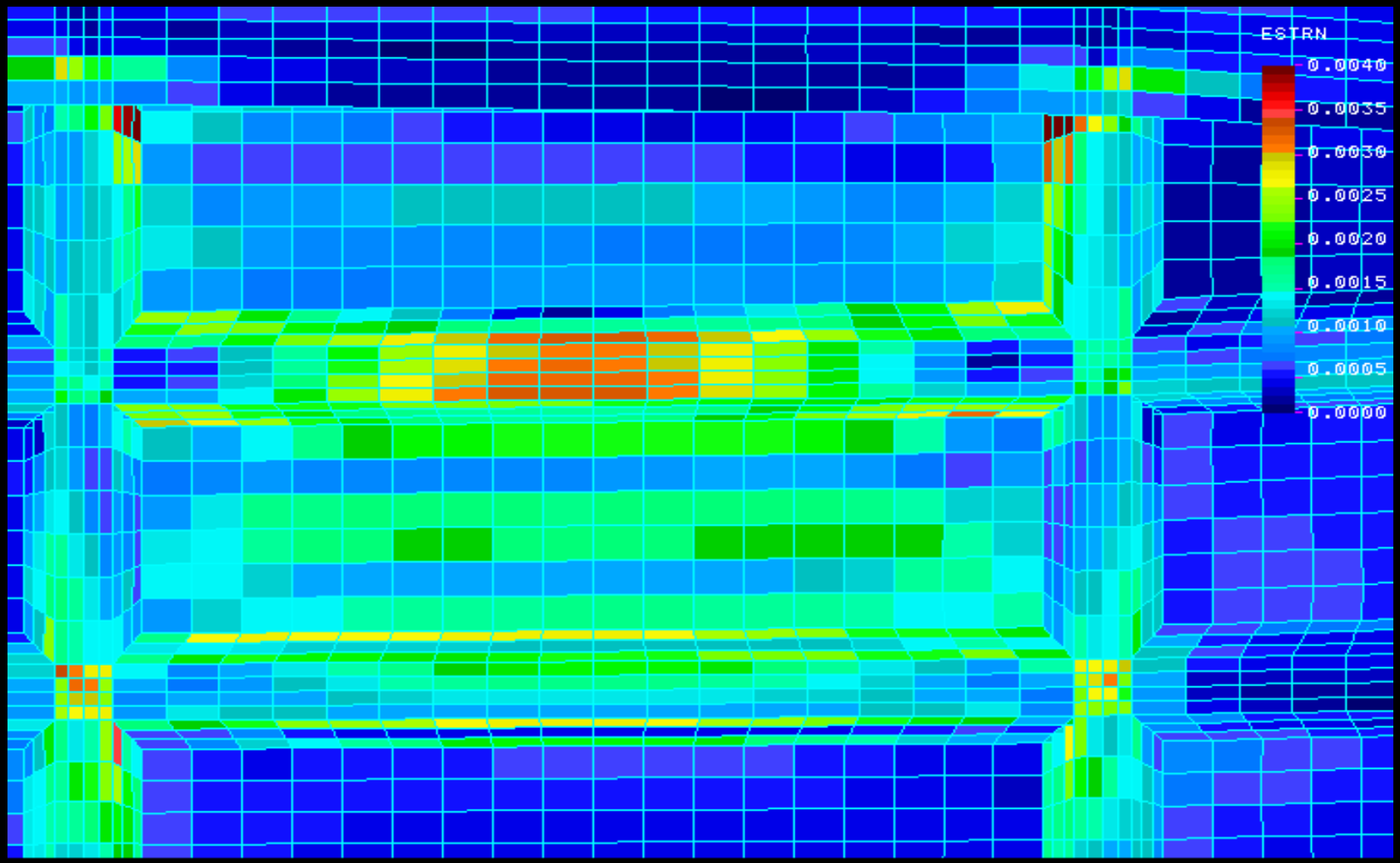
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LC4- FO- Z Displacement- Hull



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LC4- FO- Strain



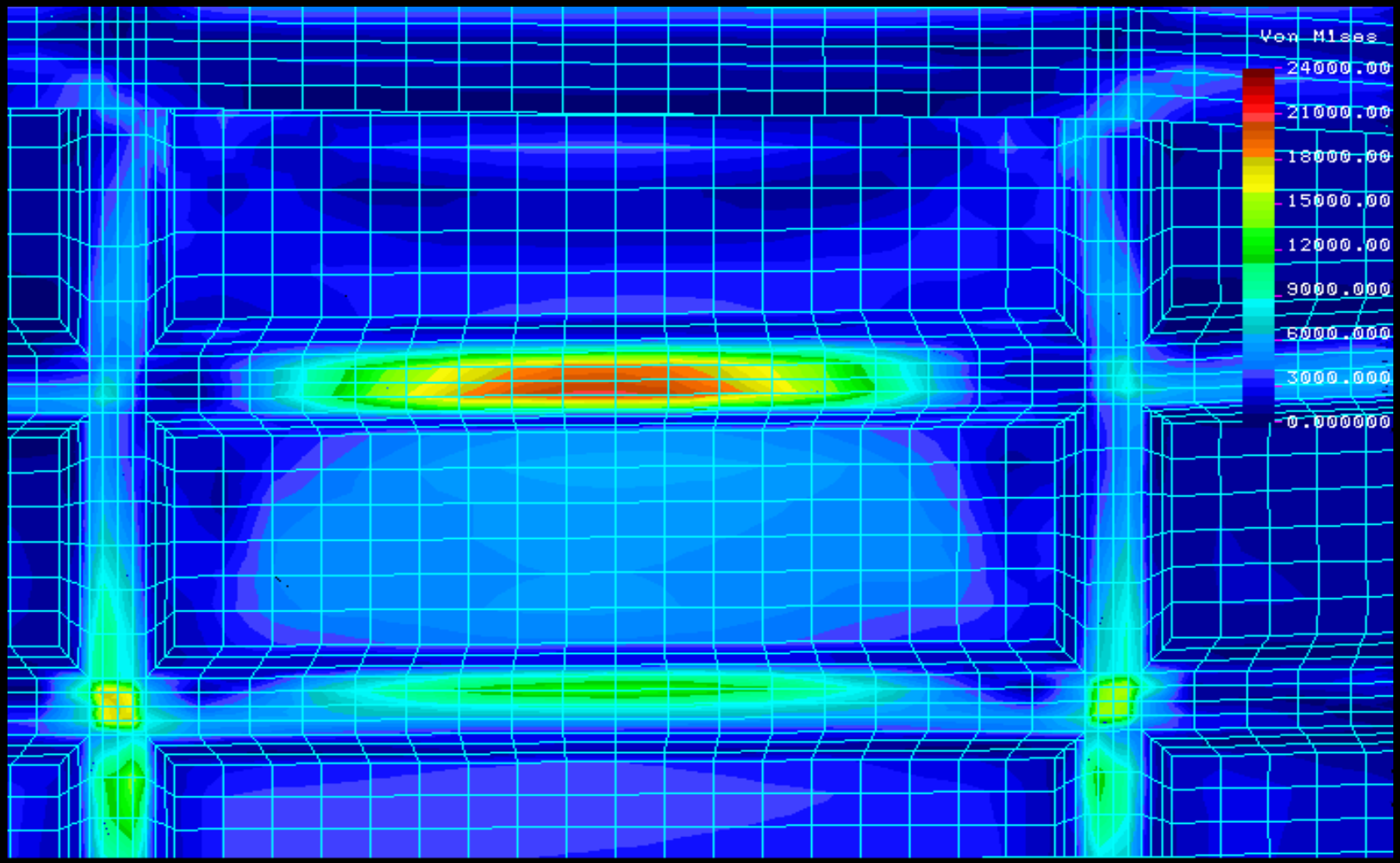
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LC4- FO- Framing Stress



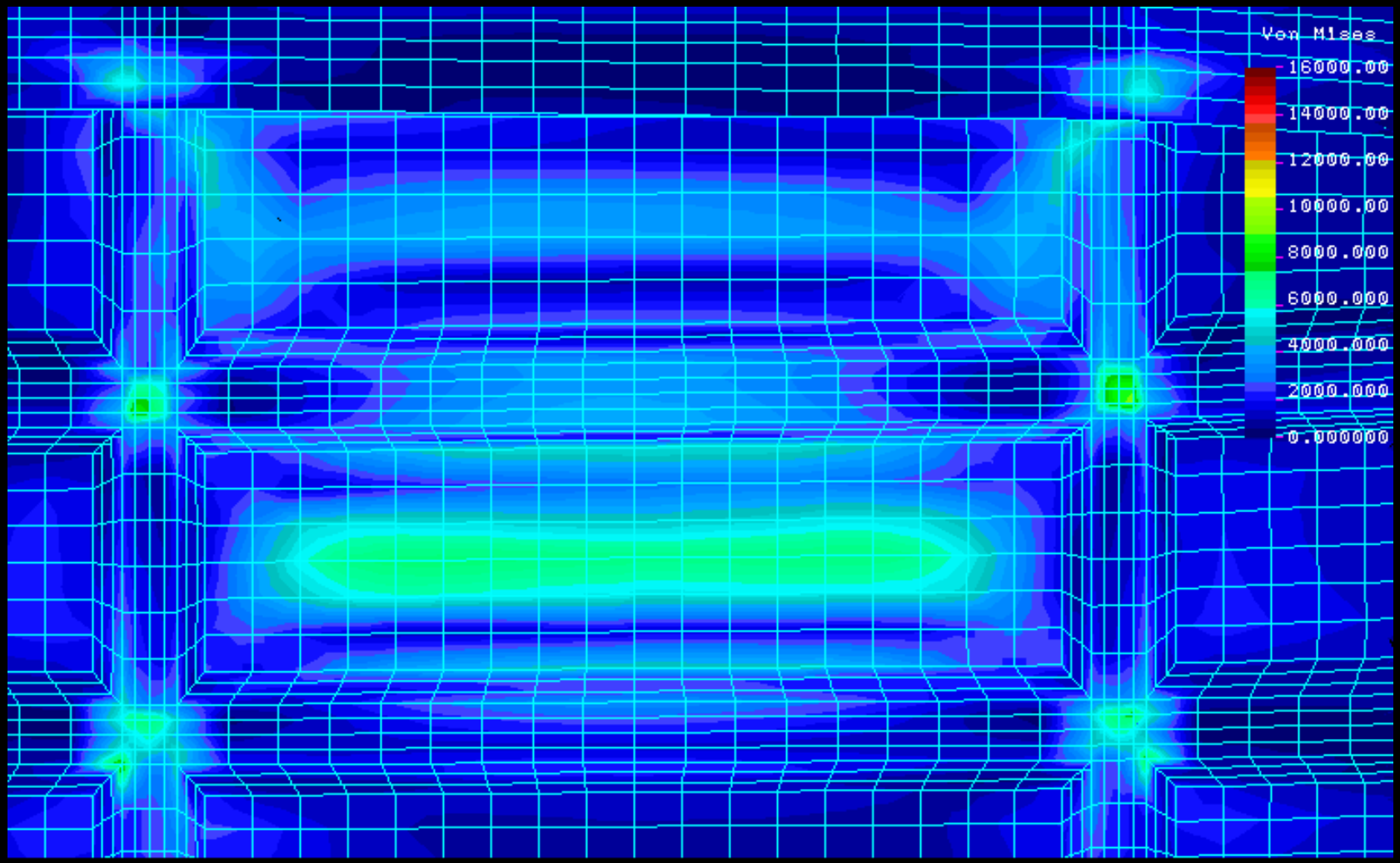
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LC4- FO- Hull Shell Stress



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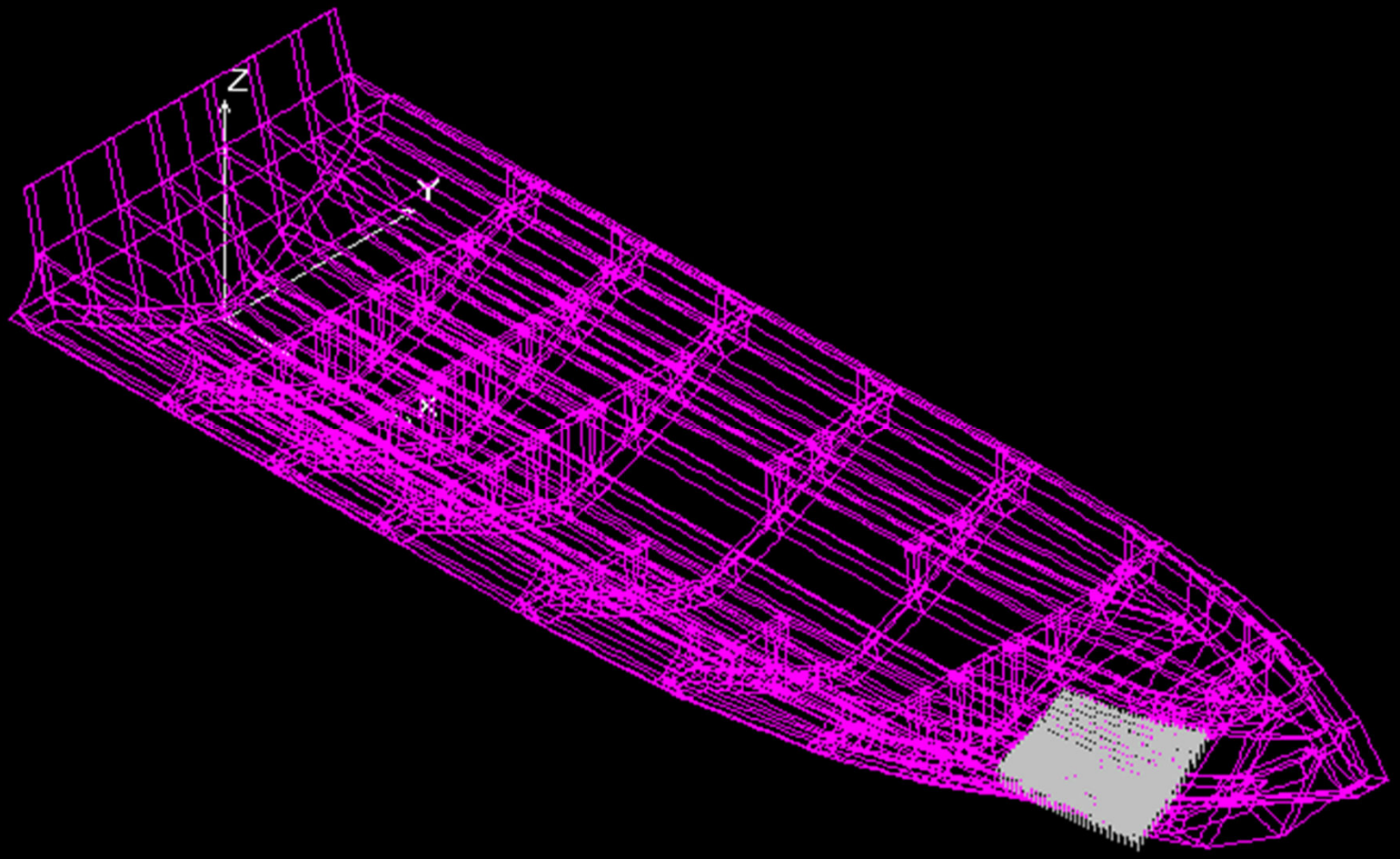
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LC4- FO- Summary

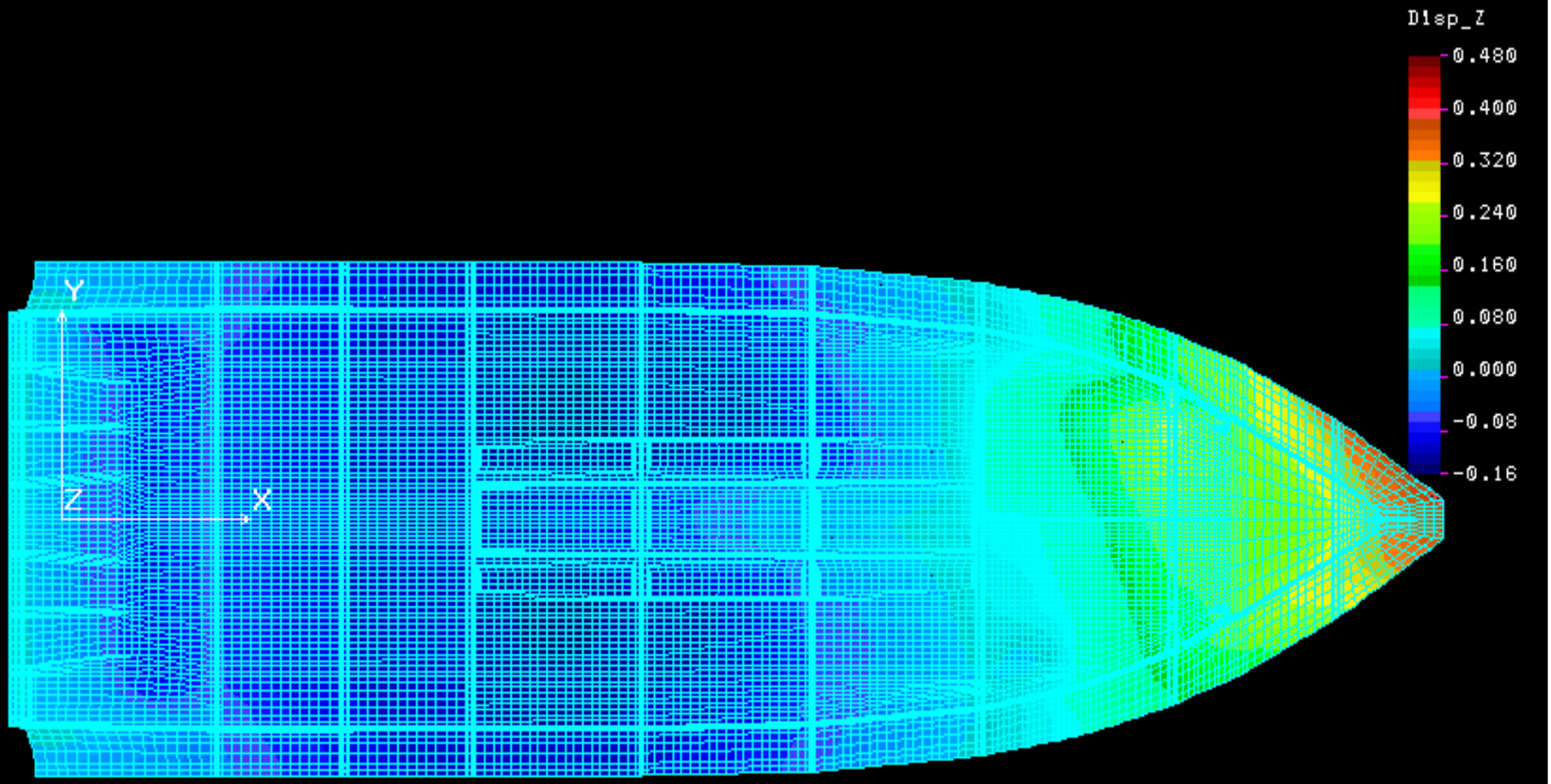
- Deck range of deflection 0.69 in.
- Hull range of deflection 1.0 in.
- Local panel deflection 0.36 in.
- Maximum strain 0.003 in/in
- Maximum framing stress 19,000 psi
- Maximum hull shell stress 5,500 psi

LC5- STR-10 psi Pressure Load



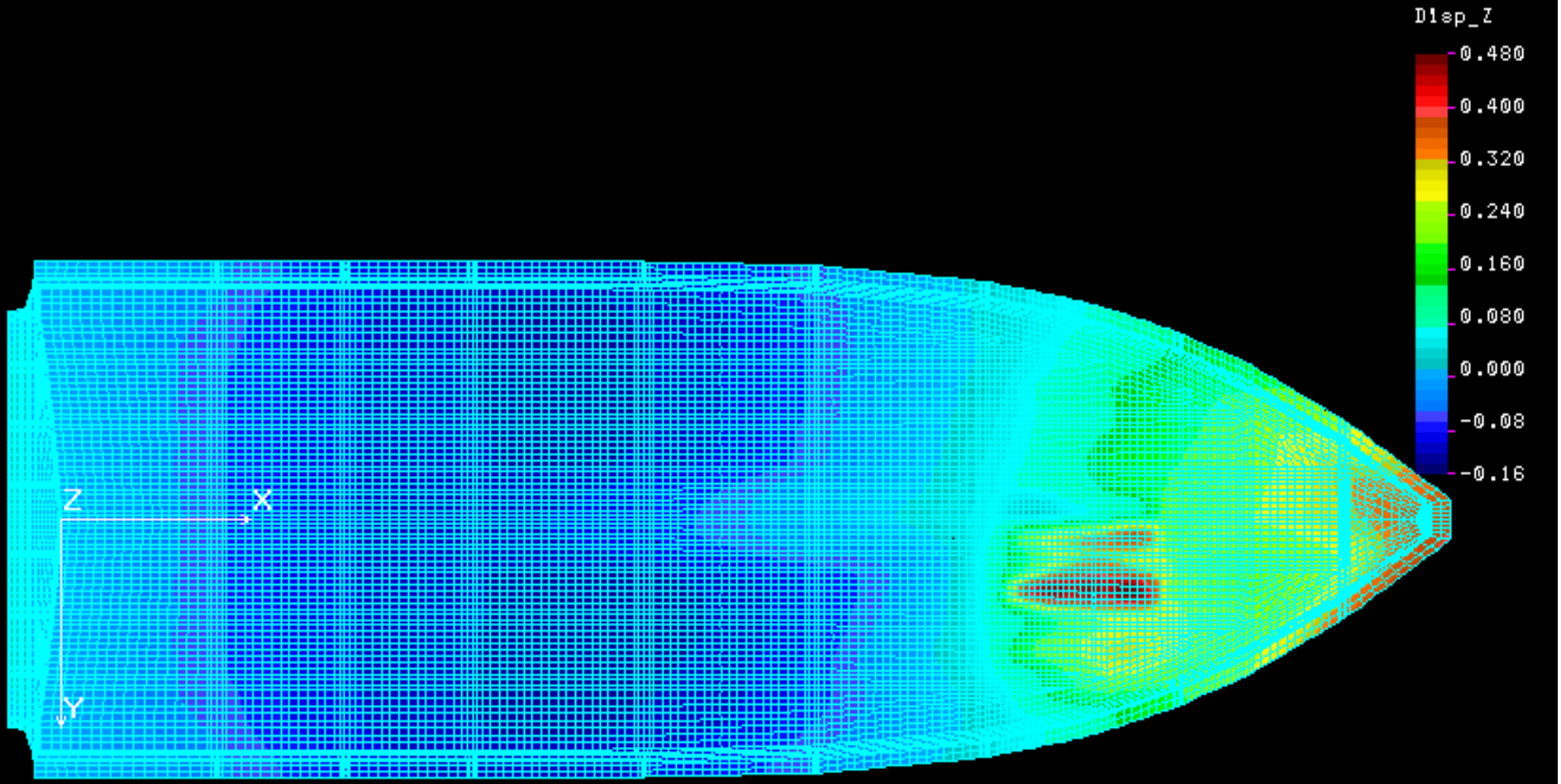
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LC5- STR- Z Displacement - Deck



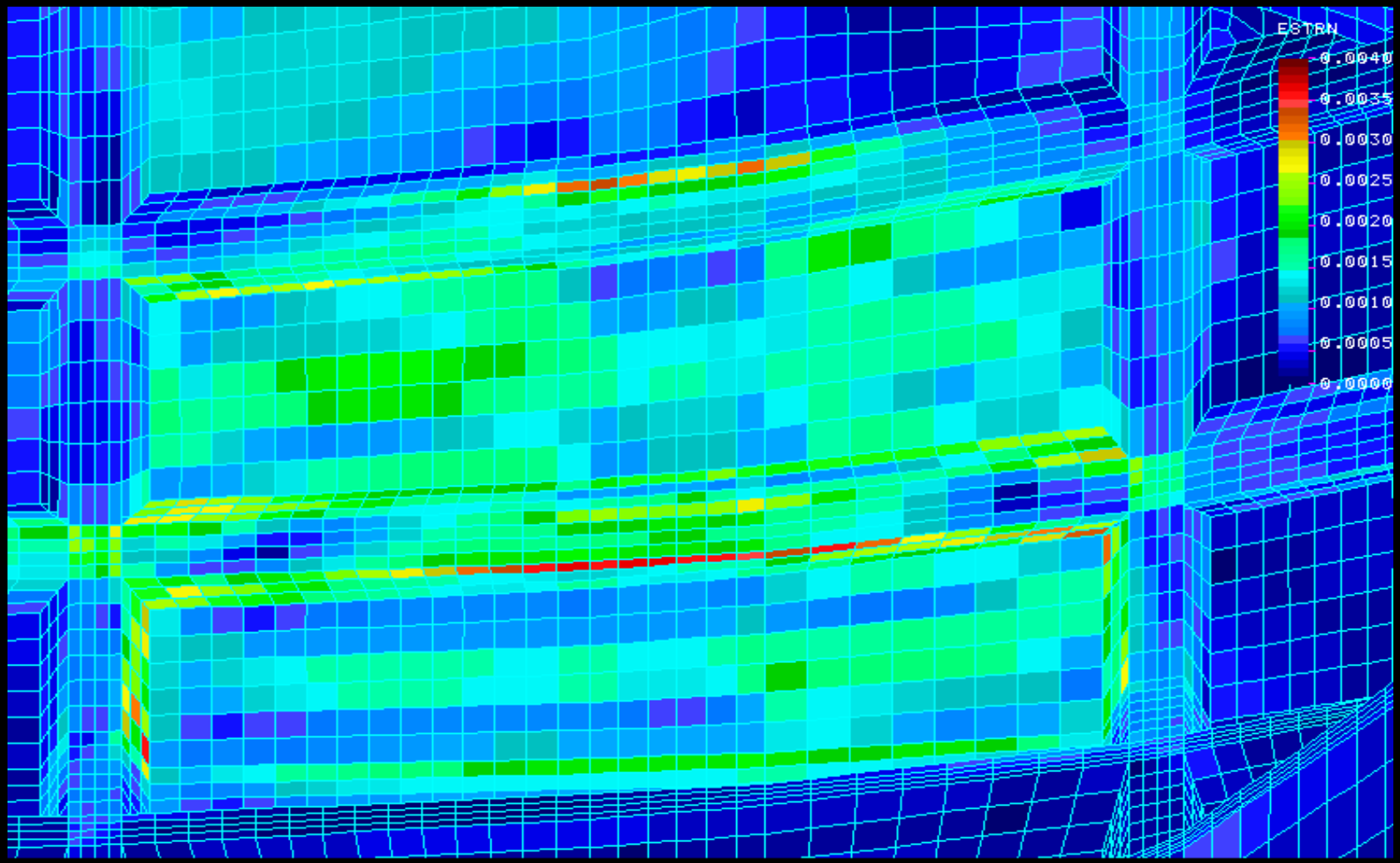
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LC5- STR- Z Displacement - Hull



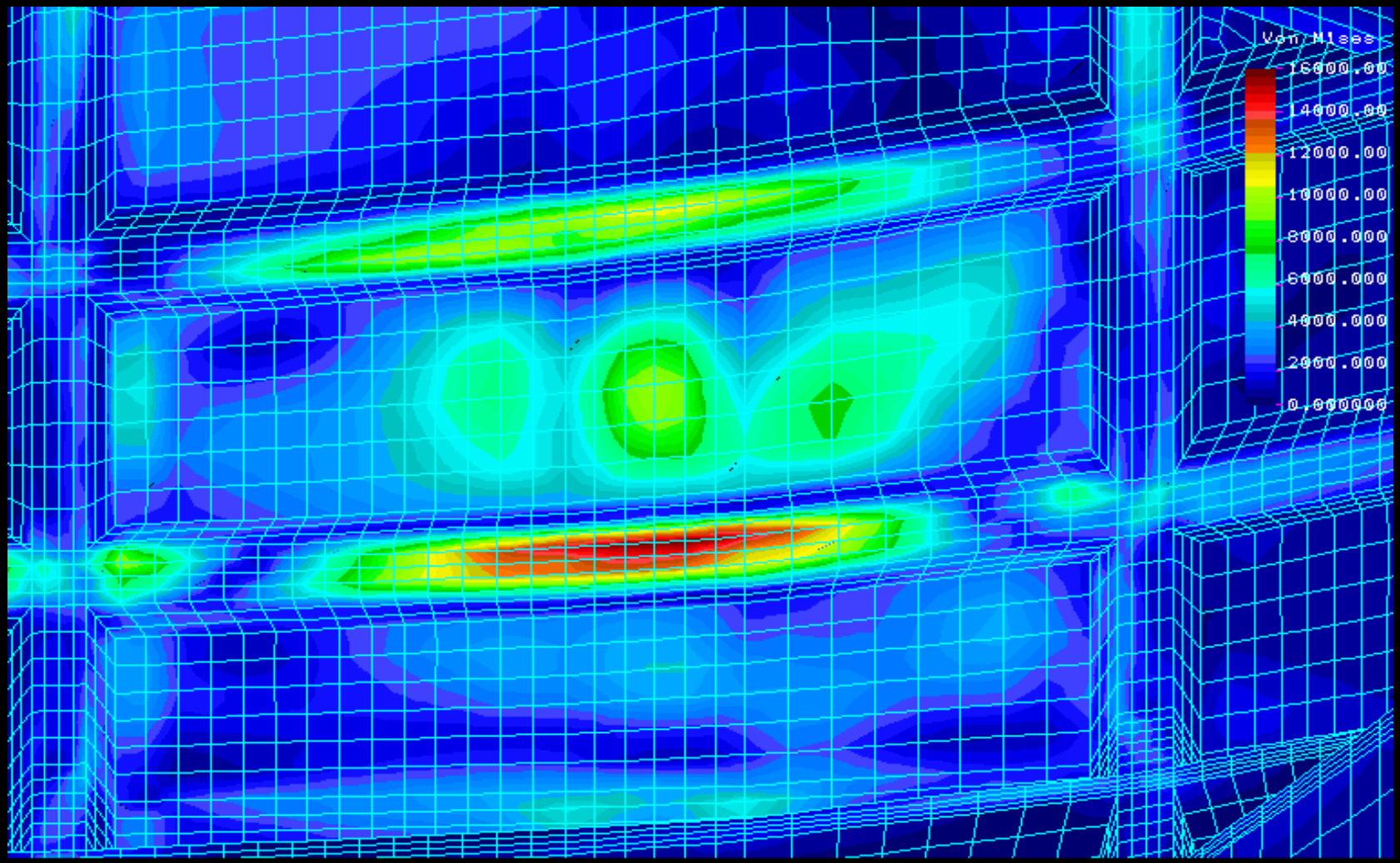
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LC5- STR- Strain



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LC5- STR- Framing Stress



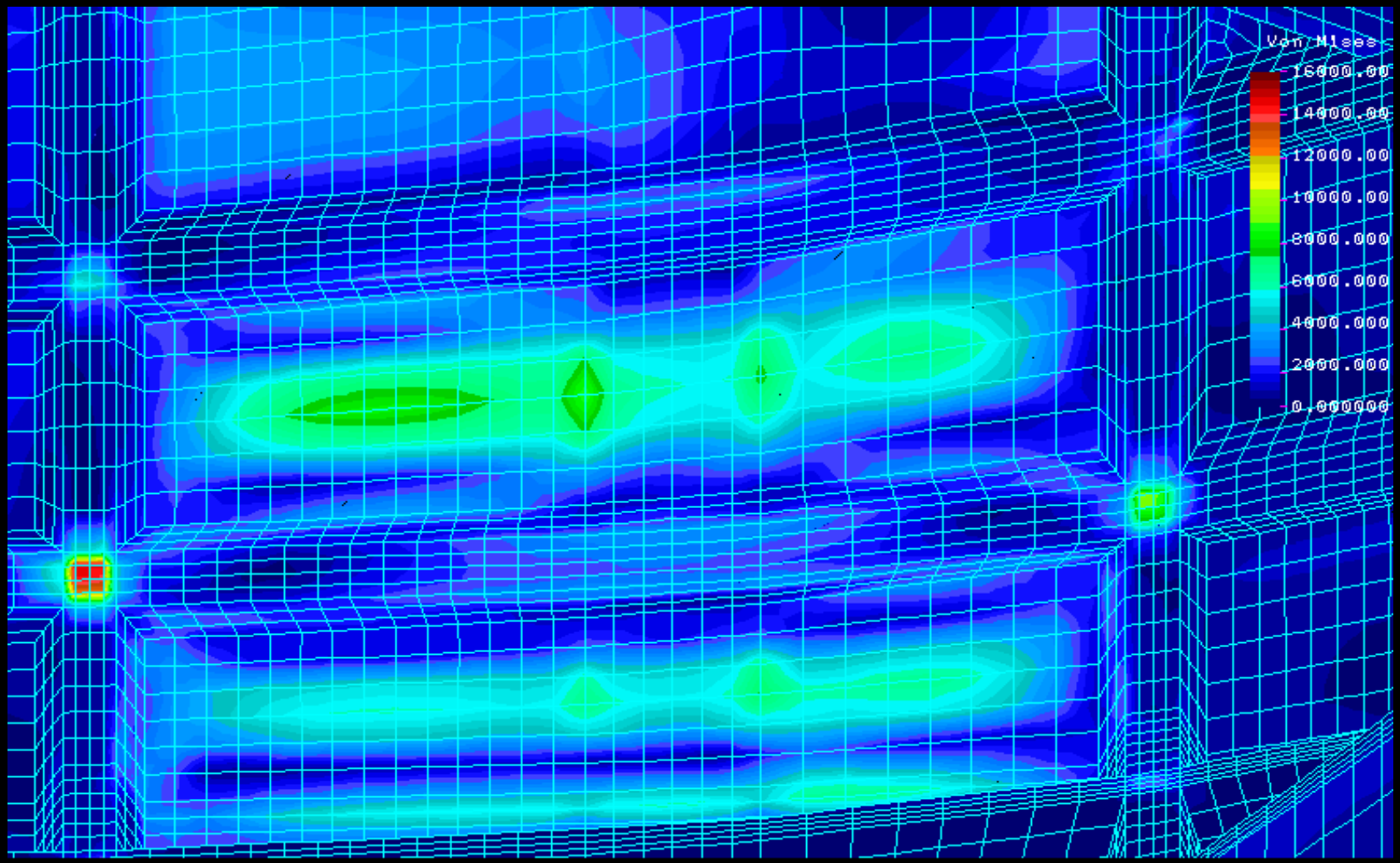
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LC5- STR- Hull Shell Stress



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LC5- STR- Summary

- Deck range of deflection 0.52 in.
- Hull range of deflection 0.64 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0035 in/in
- Maximum framing stress 14,000 psi
- Maximum hull shell stress 8,000 psi

LC(1-5)- SAS Summary

Range of maximum values in SAS cases

- Deck range of deflection 0.30-0.69 in.
- Hull range of deflection 0.44-1.0 in.
- Local panel deflection 0.16-0.36 in.
- Maximum strain 0.002-0.0035 in/in
- Maximum framing stress 9,000-19,000 psi
- Maximum hull shell stress 5,000-8,000 psi

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850A- FEA Analysis: Large Area Slam (LAS)







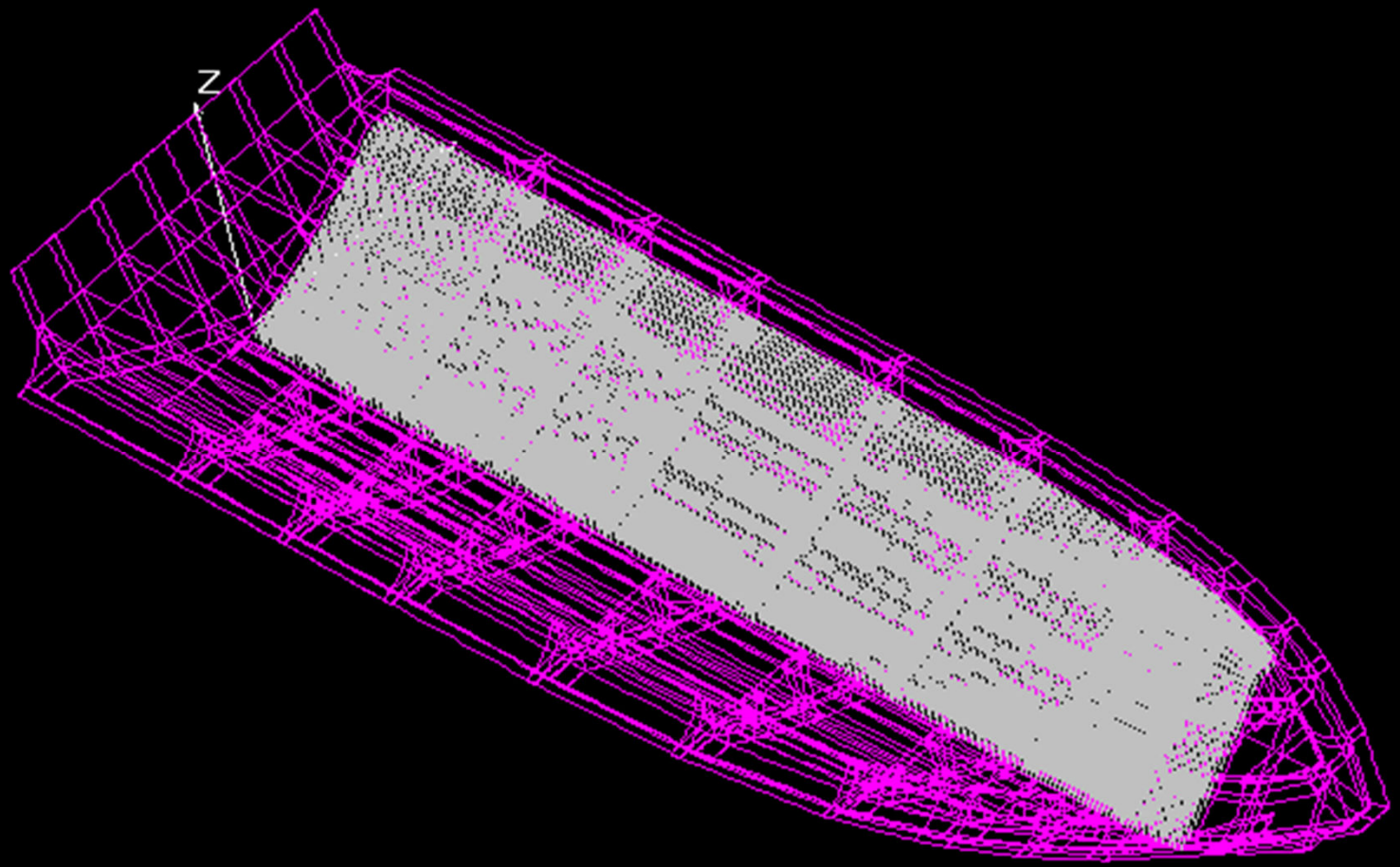




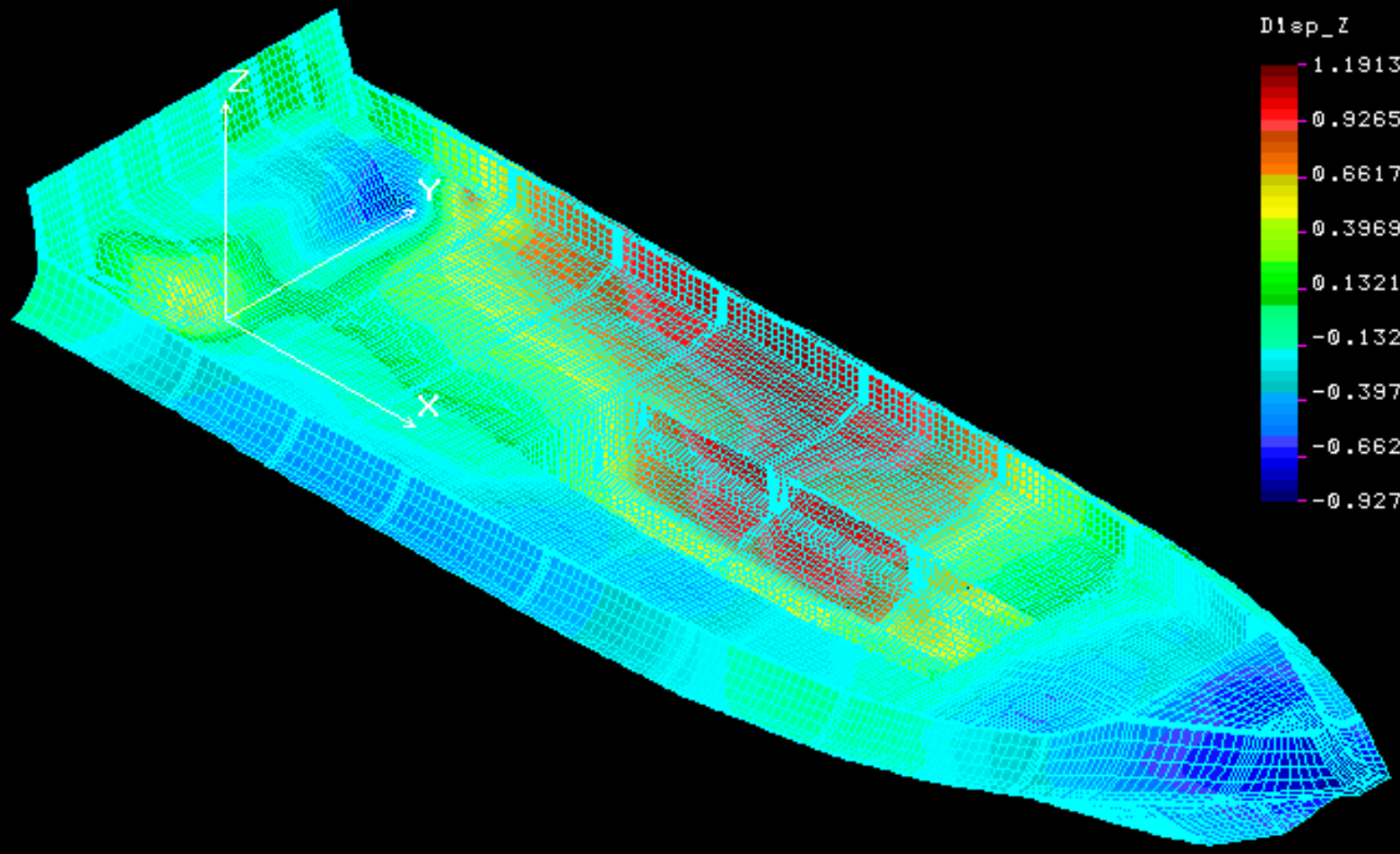
LC6-LAS- Loading

- Pressure load 4.68 psi
- Total load 44,000 lbs
- 11,000 lbs running weight at 4 g's

LC6-LAS- 4.68psi Pressure Load



LC6-LAS- Z Displacement - Deck



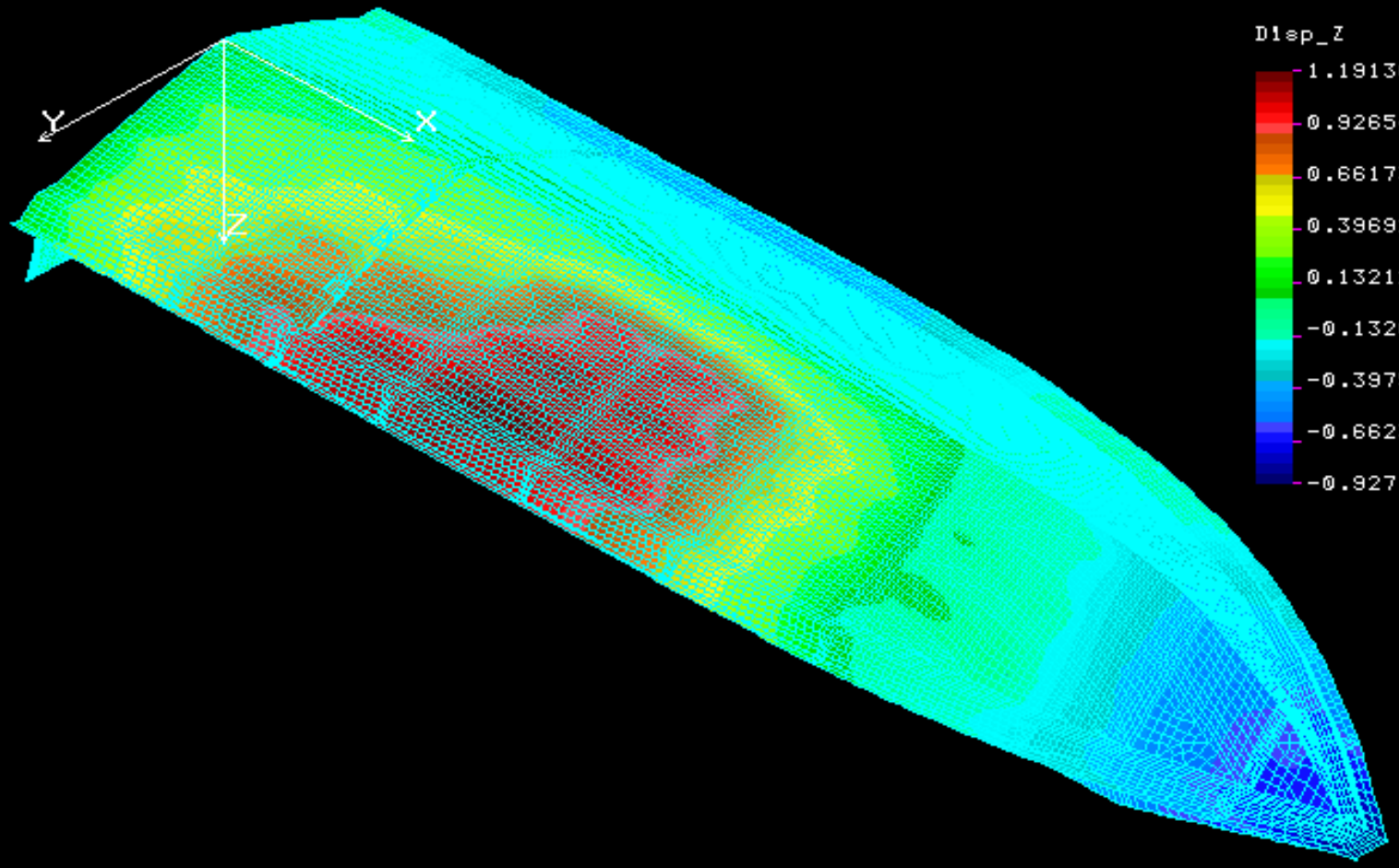
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LC6-LAS- Z Displacement - Hull



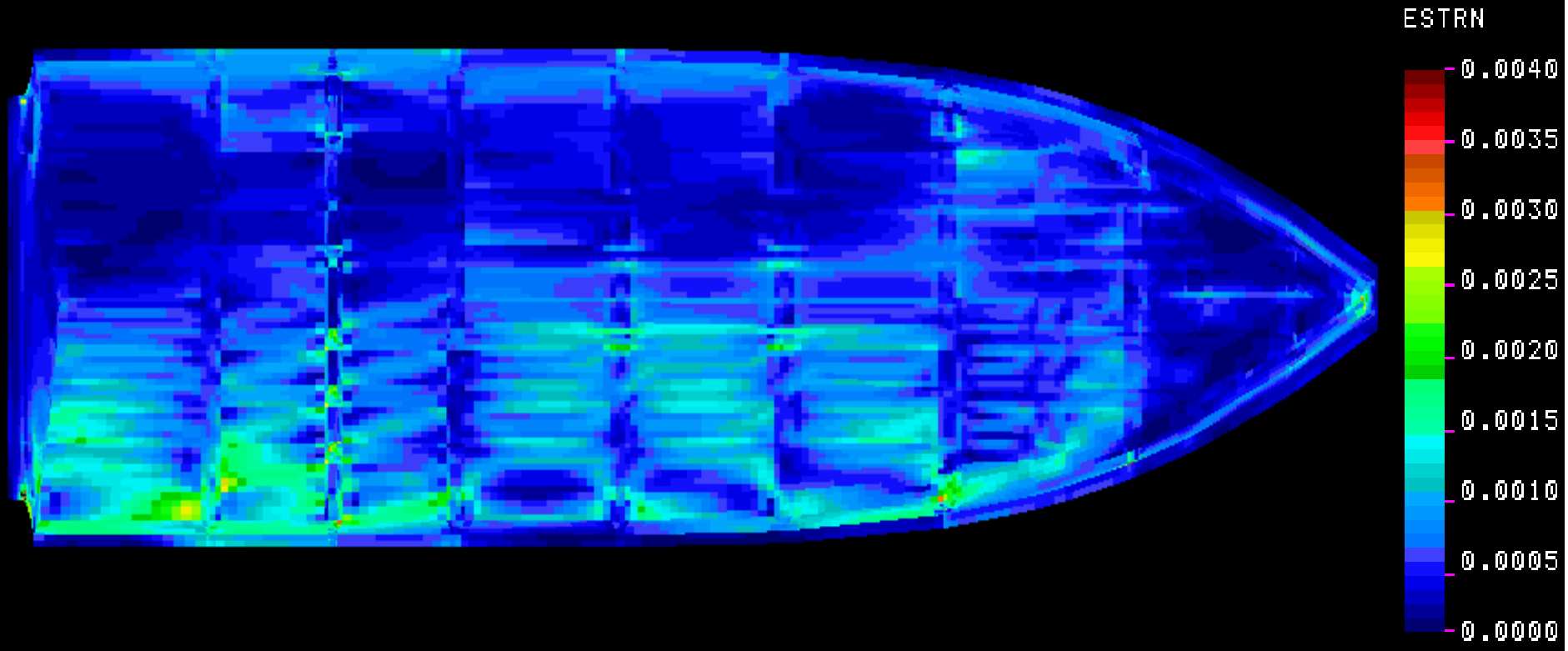
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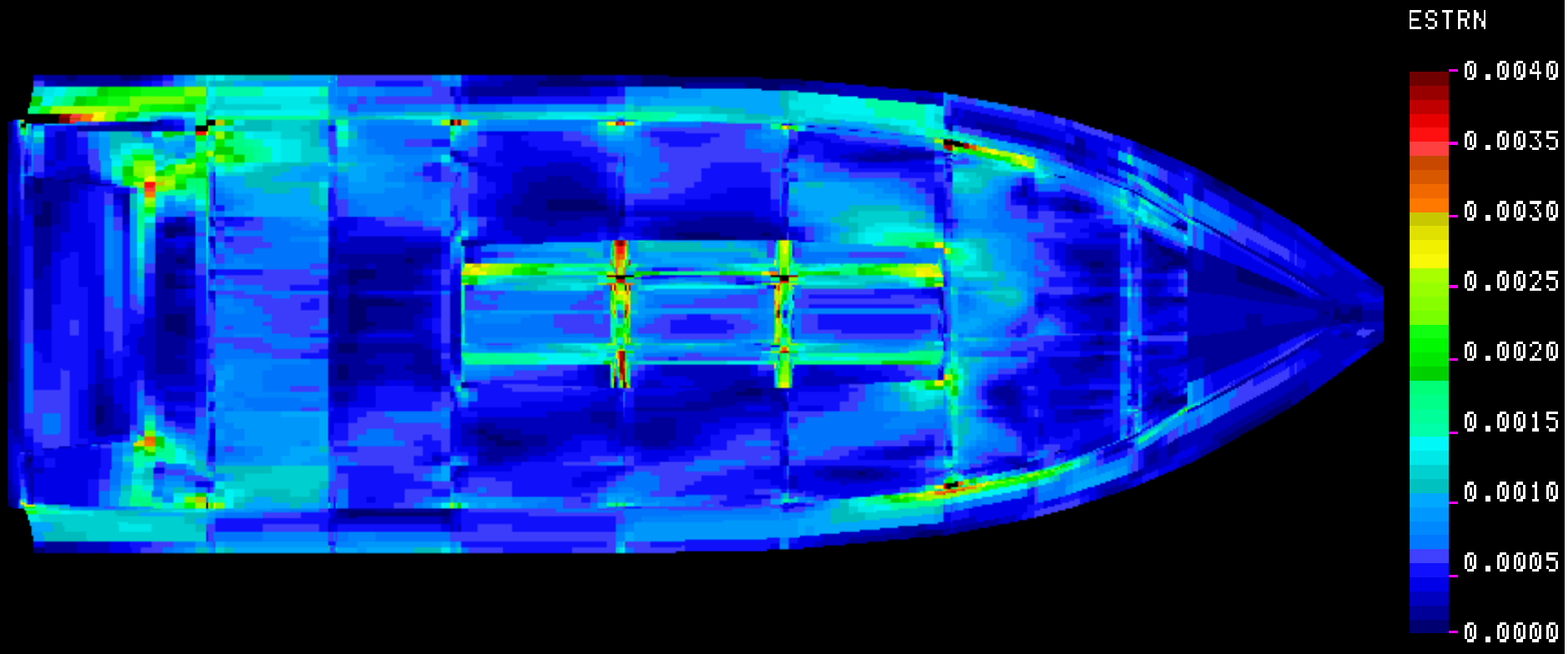
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LC6-LAS- Hull Shell Strain



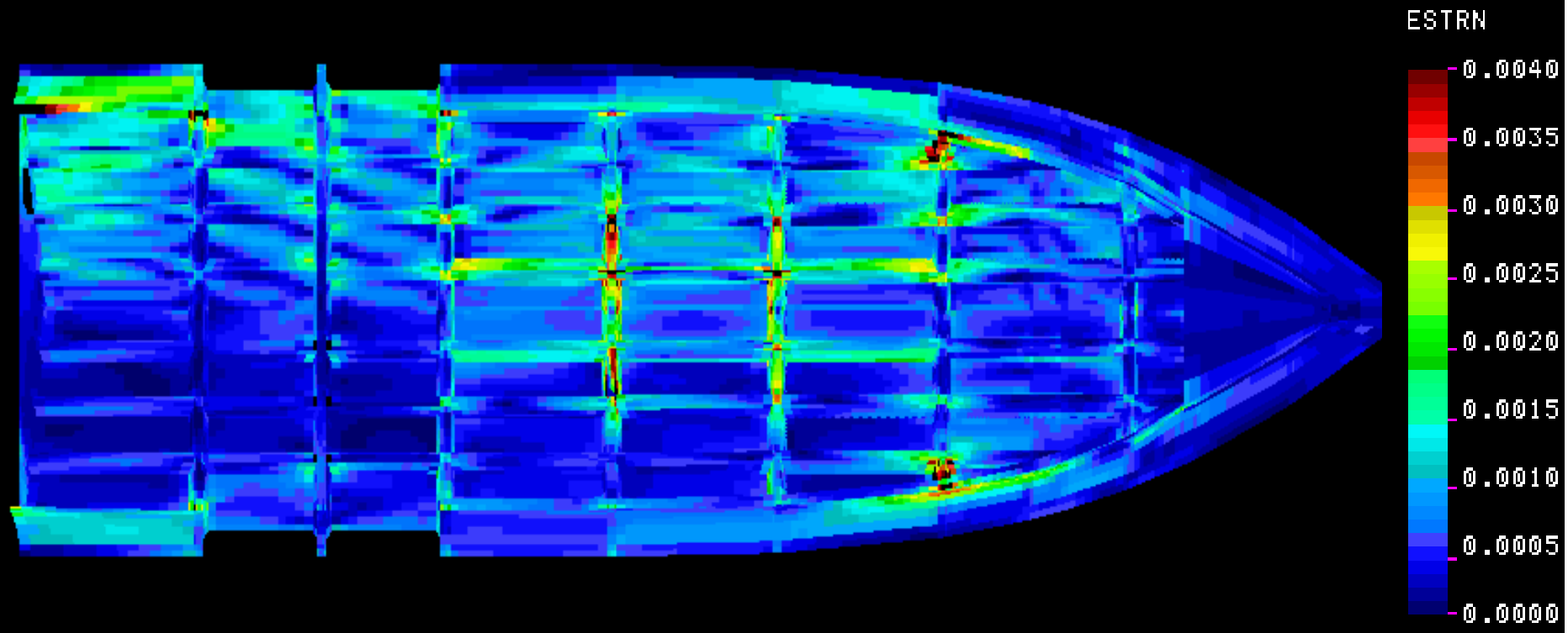
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LC6-LAS- Deck Strain



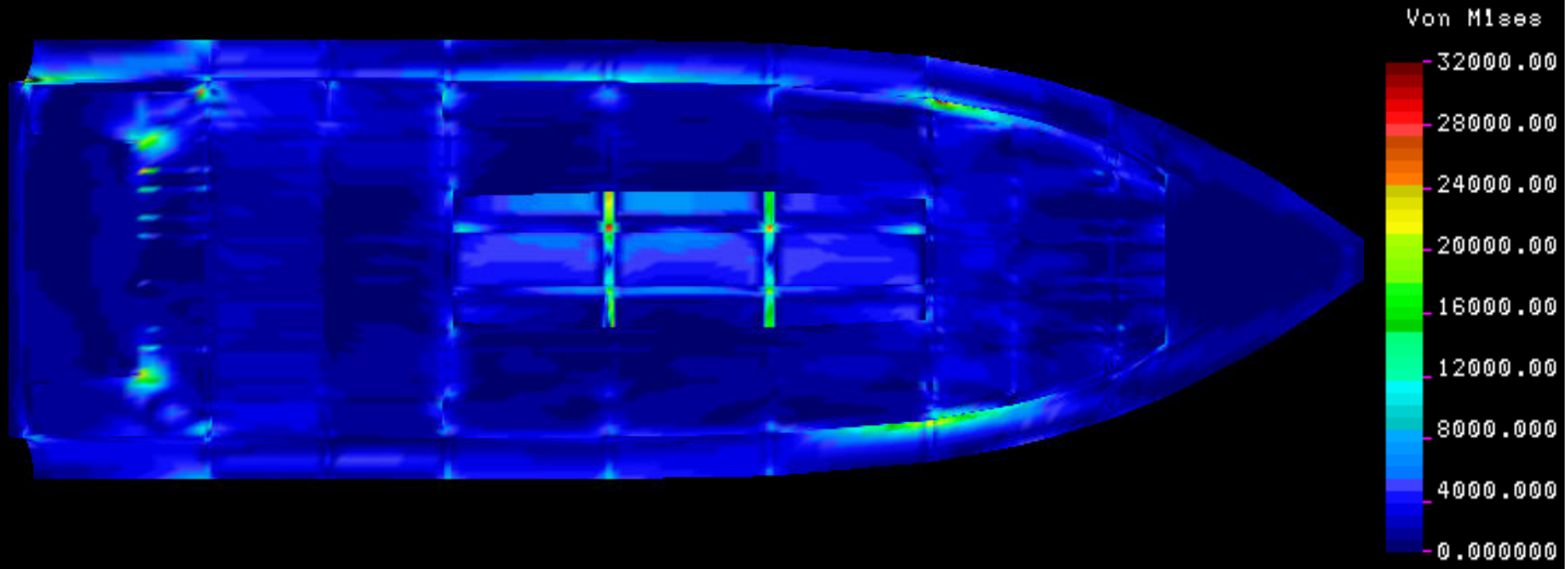
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LC6-LAS- Framing Strain



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LC6-LAS- Deck Longitudinal Stress



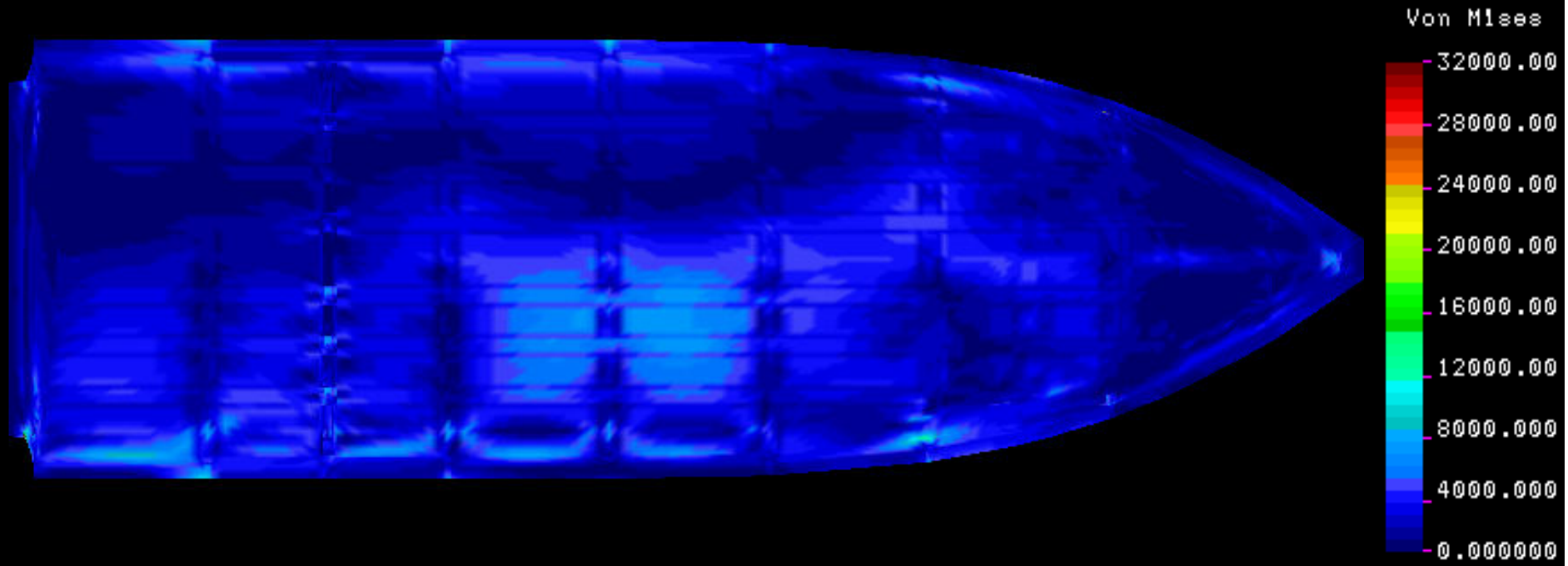
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LC6-LAS- Hull Shell Longitudinal Stress



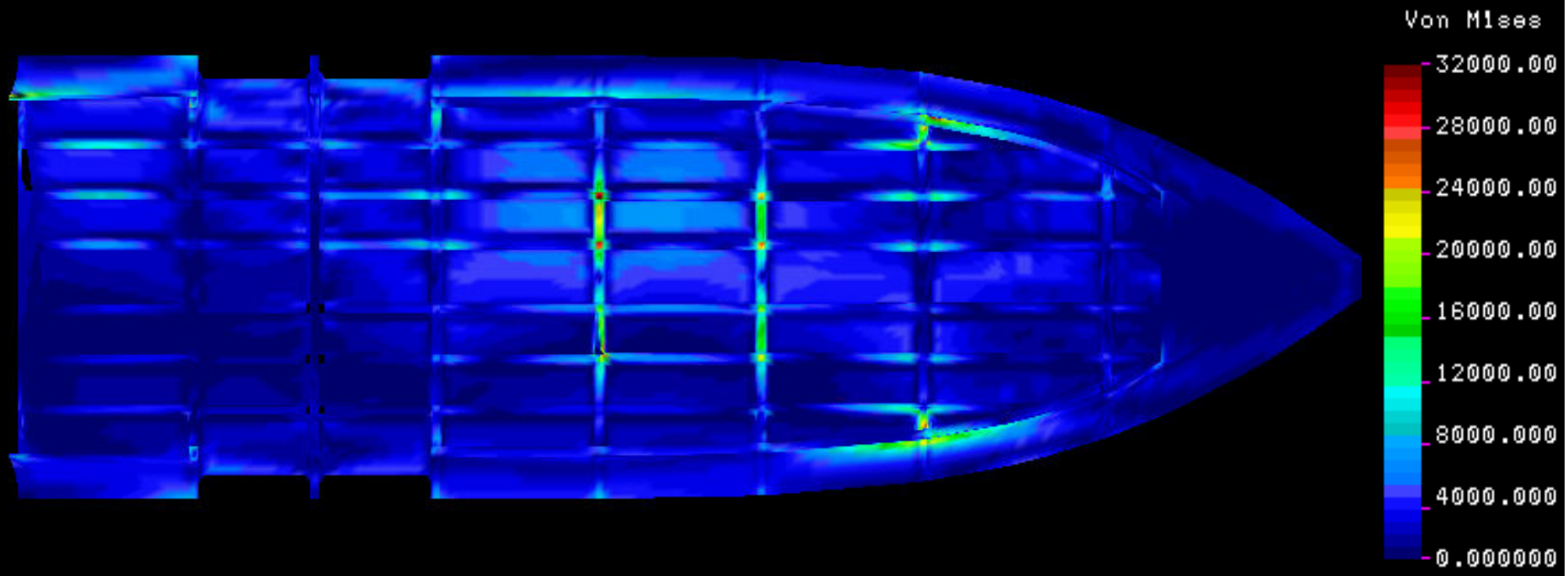
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LC6-LAS- Frame Longitudinal Stress



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LC6-LAS- Deck Transverse Stress



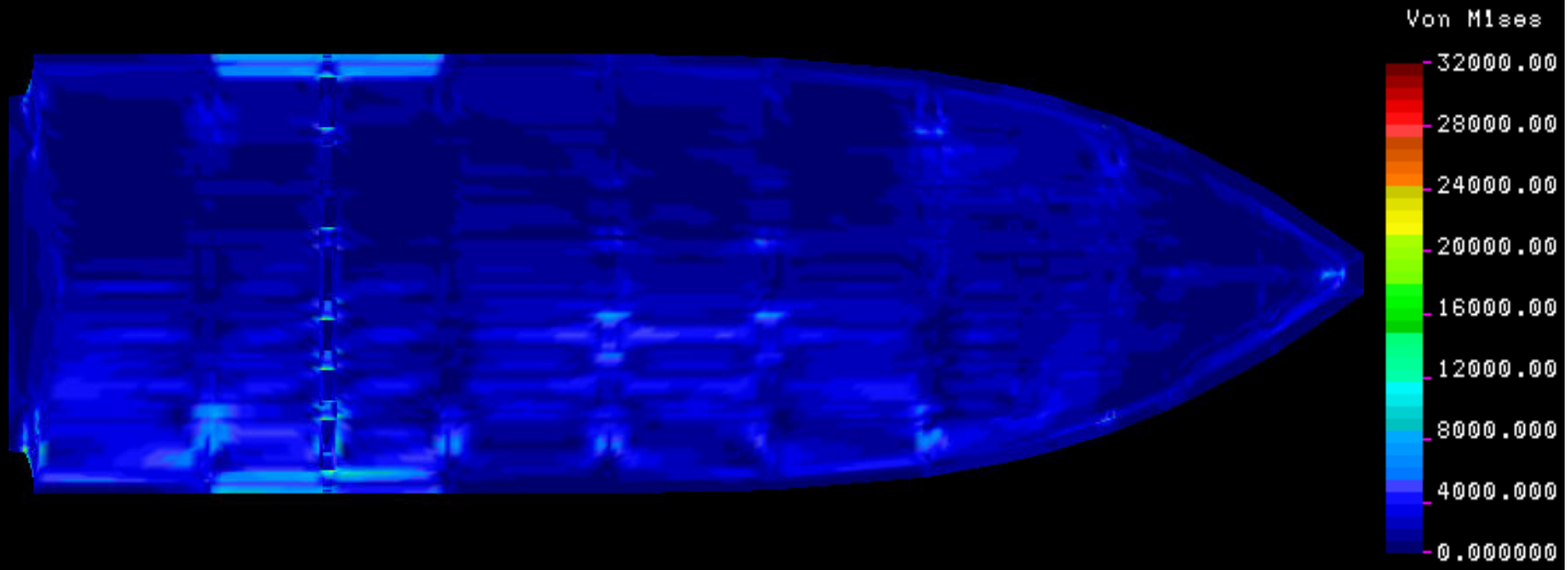
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LC6-LAS- Hull Transverse Stress



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850A- LAS Summary

- Deck range of deflection 1.72 in.
- Hull range of deflection 2.19 in
- Maximum strain 0.025 in/in
- Local panel deflection 0.17 in.
- Maximum longitudinal stress 13,500 psi
- Maximum transverse stress 12,000 psi

850A- FEA Analysis: Calm Water Planning (C.W.P.)

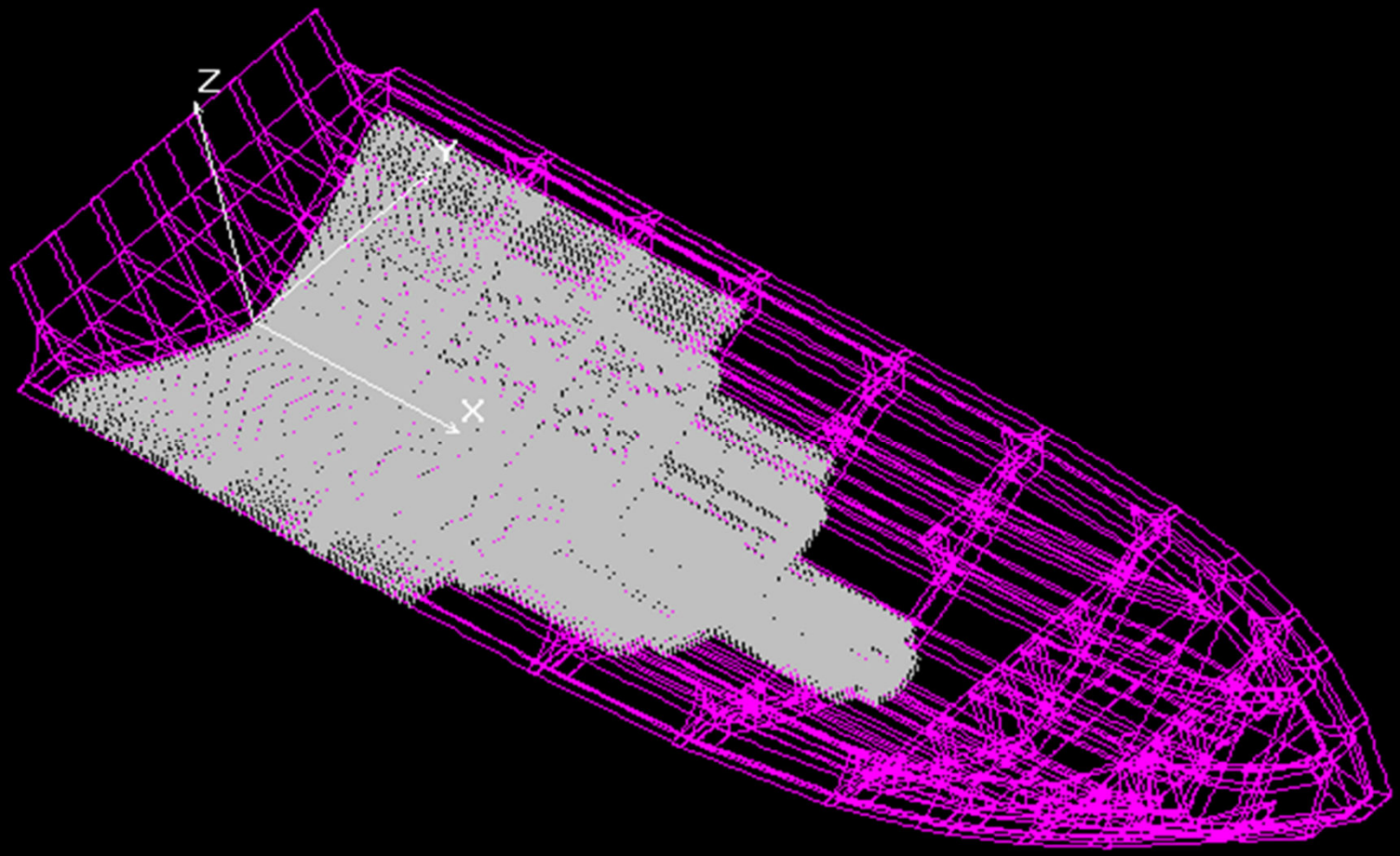


LC7-CWP- Load

- Boat weight 11,000 lbs
- Bottom pressure 1.1 psi (11,000 lbs total)

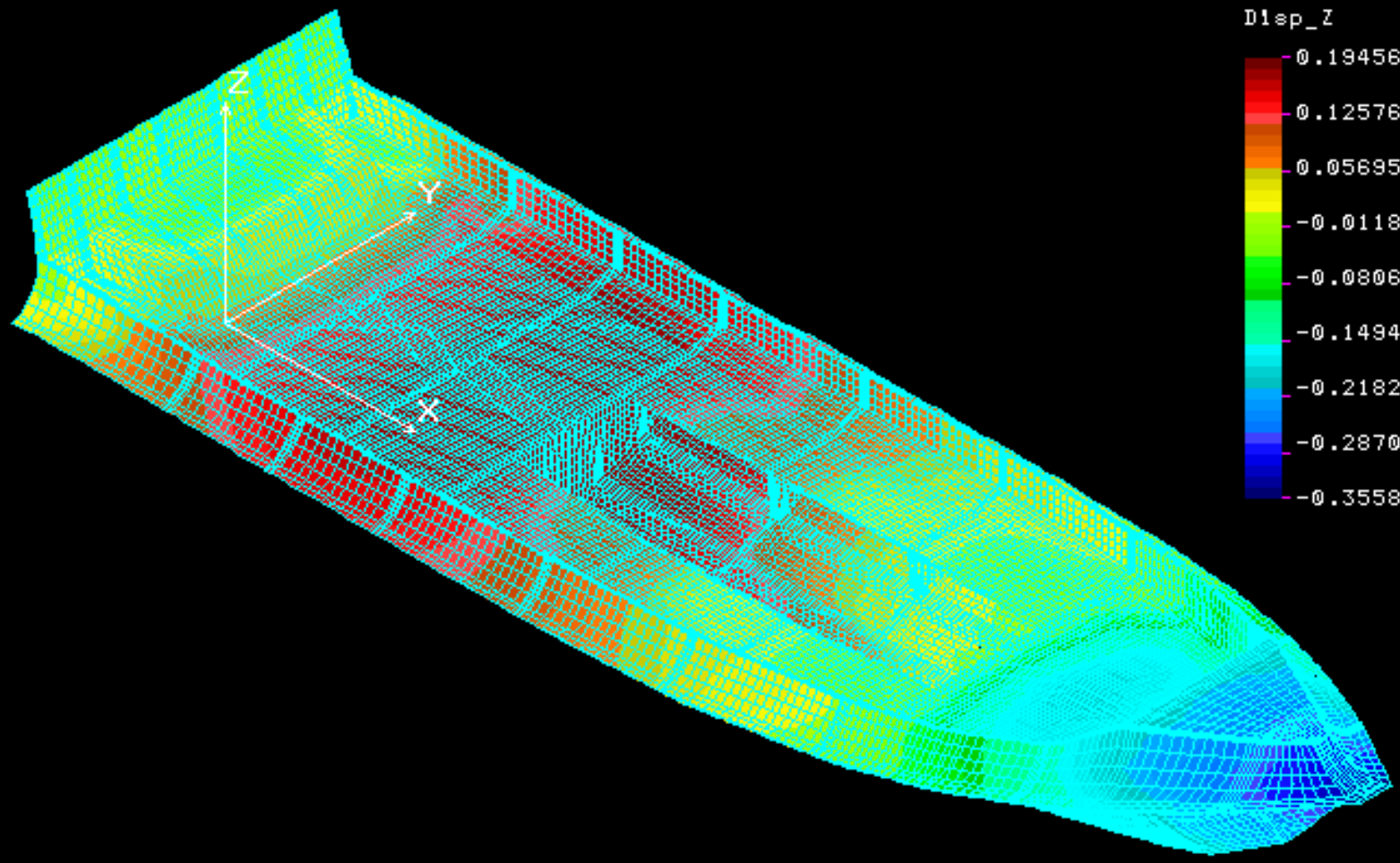
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LC7-CWP- 1.1psi Pressure Load



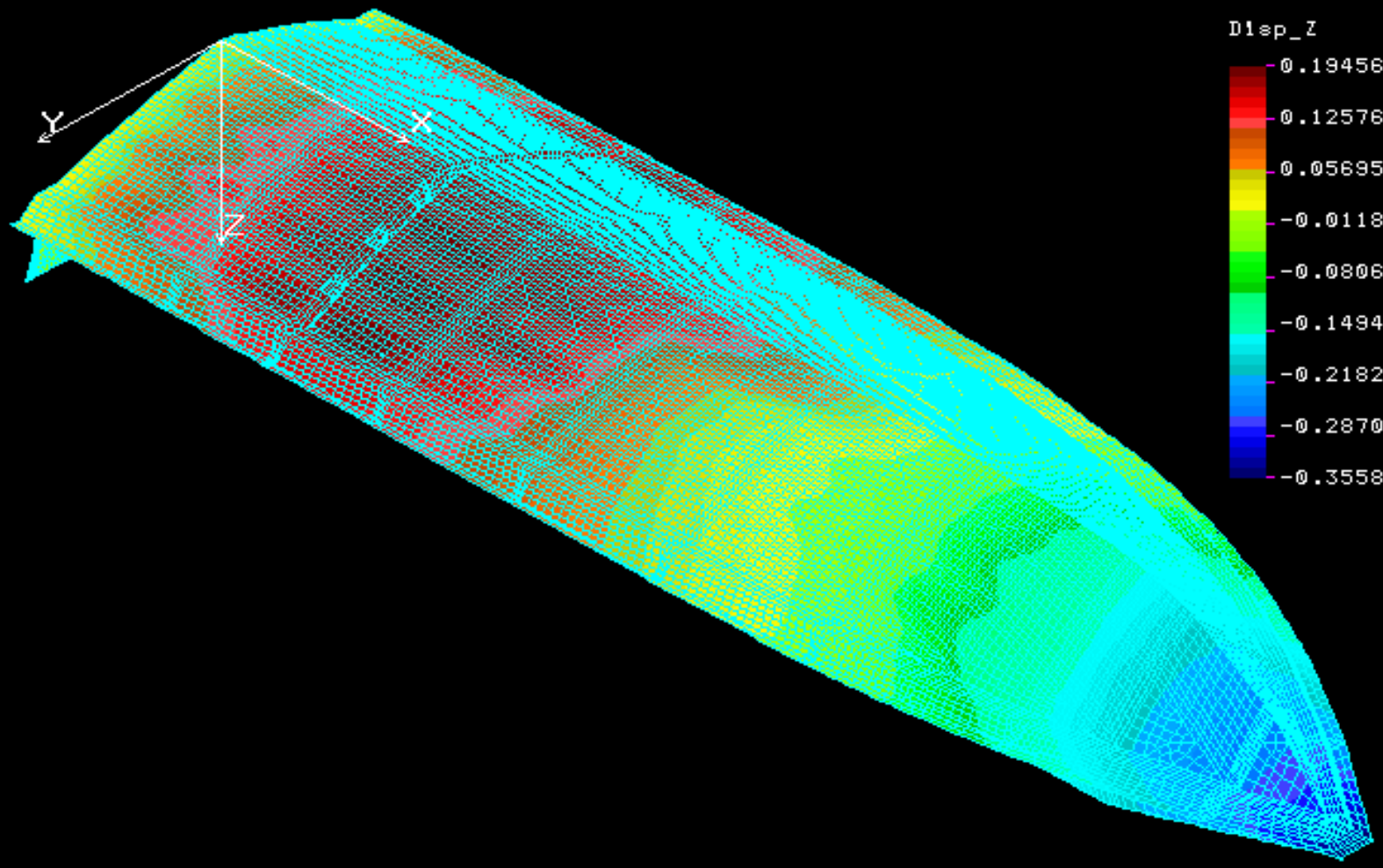
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LC7-CWP- Deck Deflection



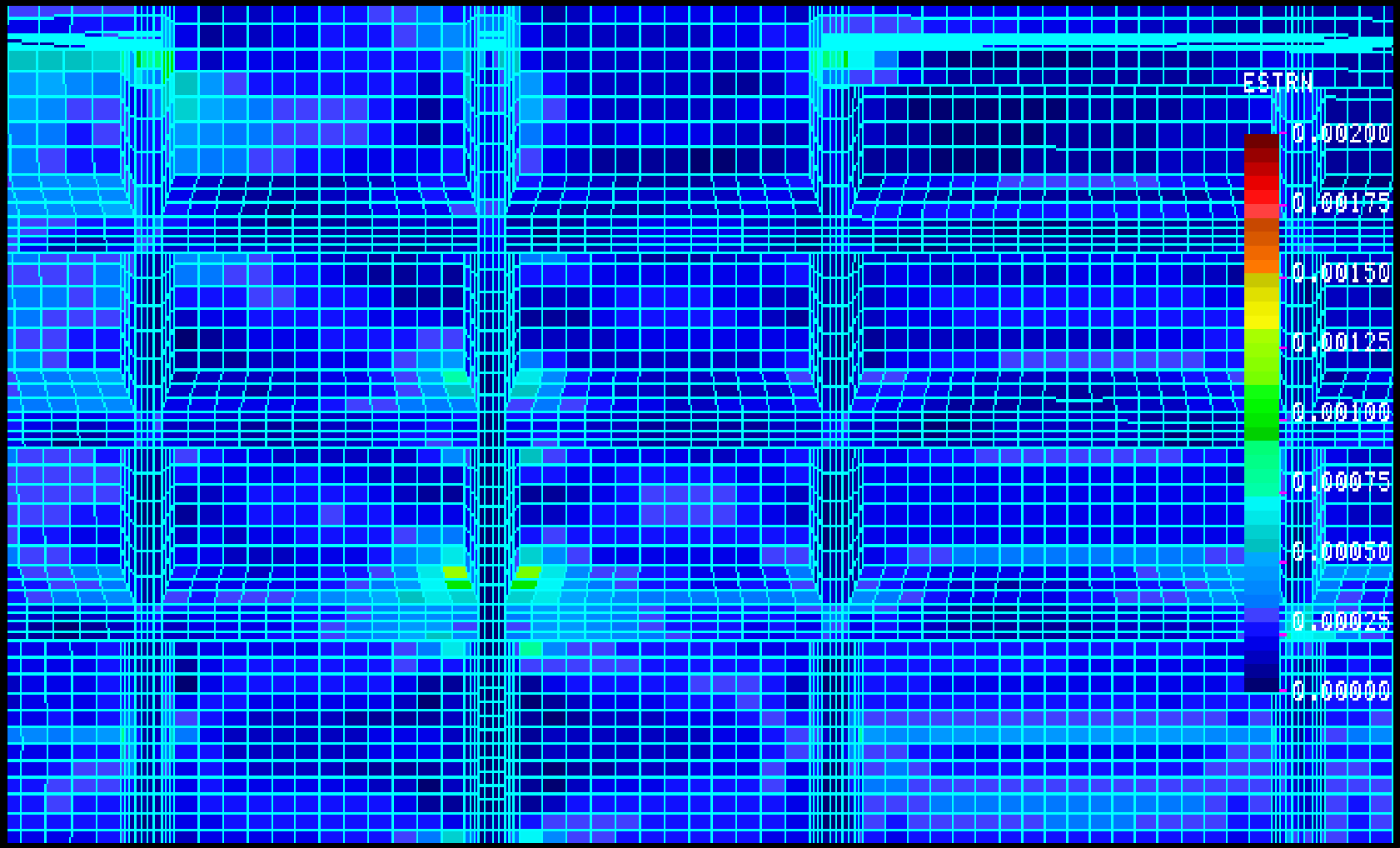
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LC7-CWP- Hull Deflection



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LC7-CWP- Strain



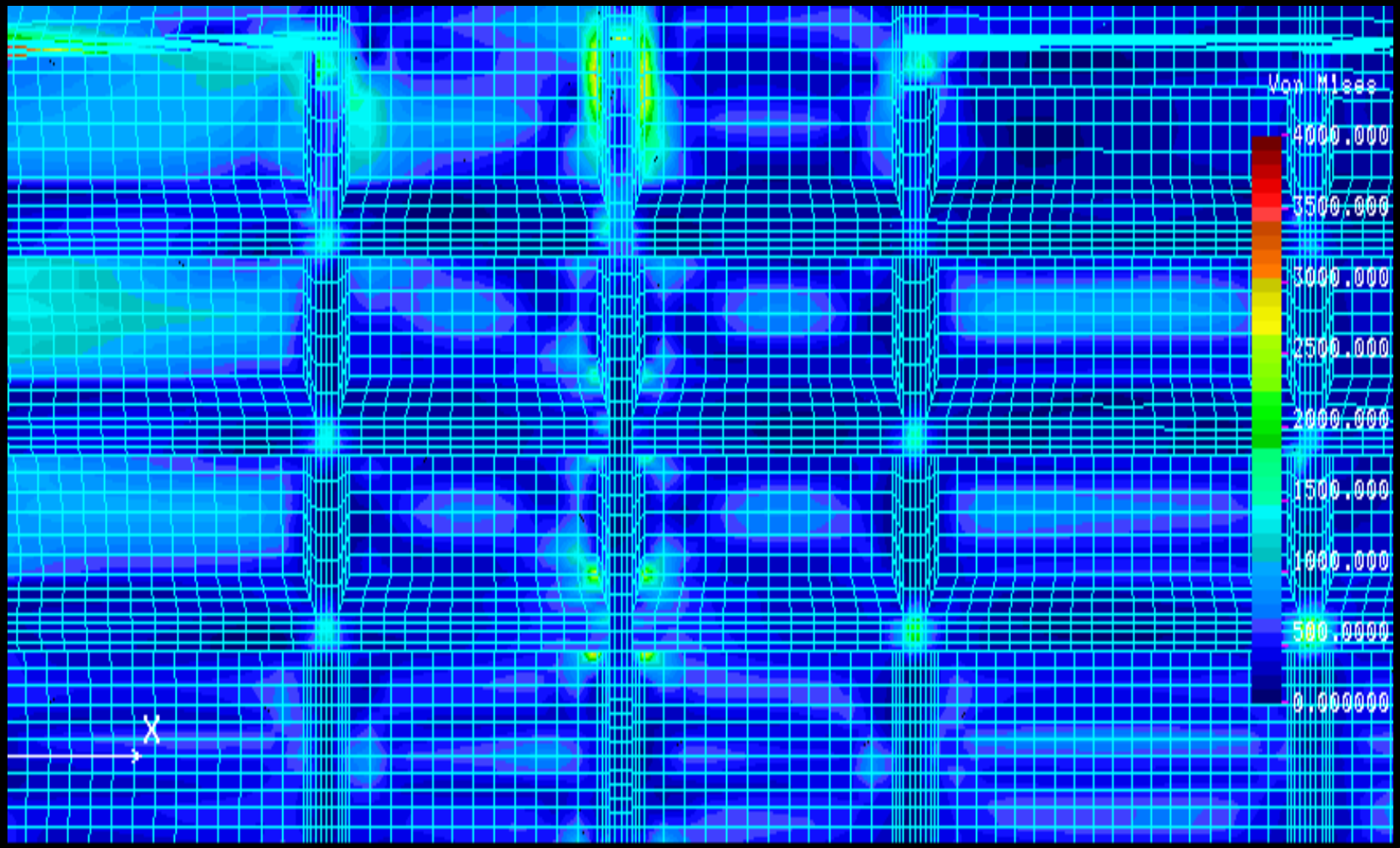
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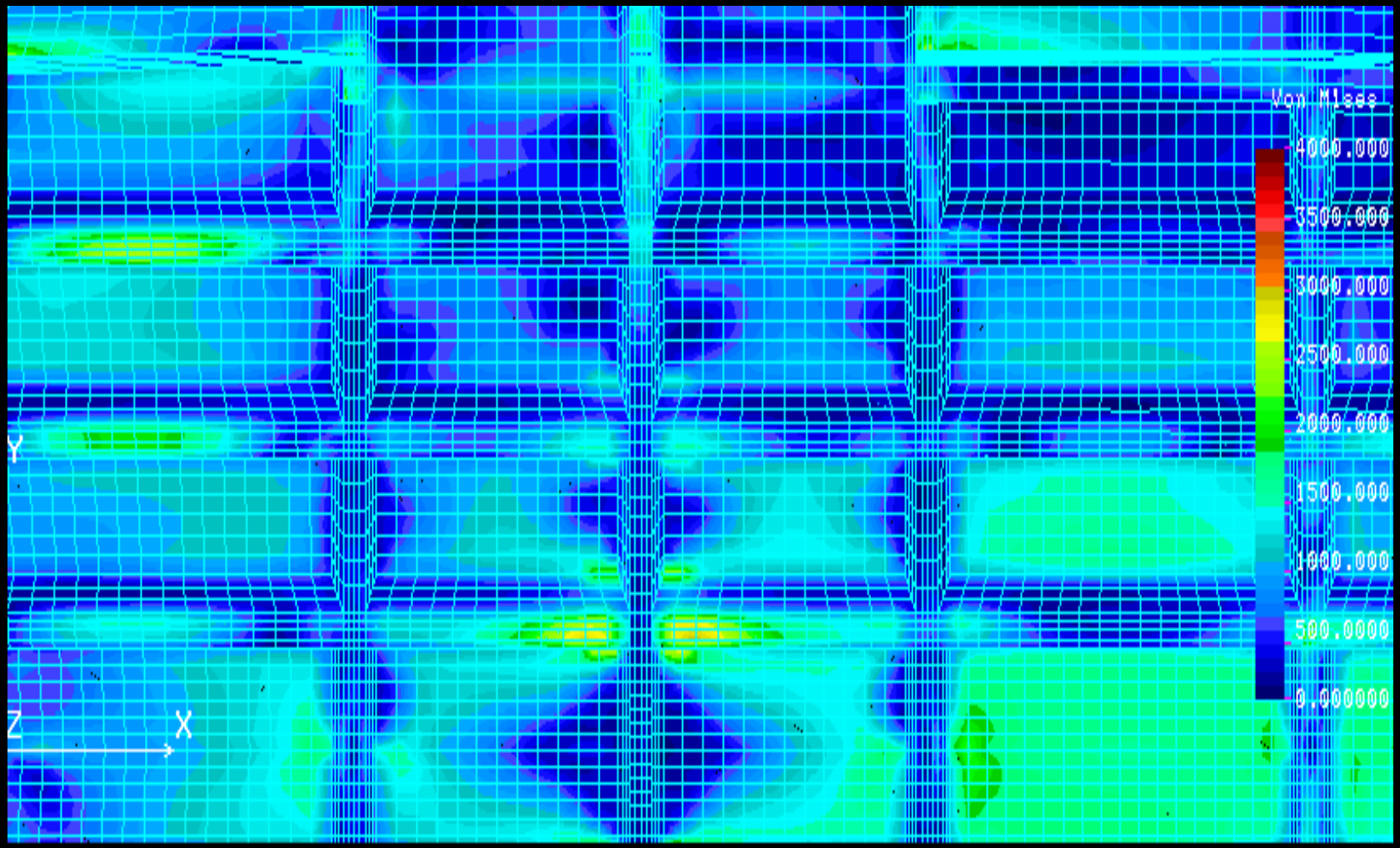
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LC7-CWP- Transverse Stress



LC7-CWP- Longitudinal Stress



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850A- CWP Summary

- Range of deflection 0.52 in.
- Local panel deflection 0.025 in
- Maximum strain 0.0007 in/in
- Maximum longitudinal stress 2000 psi
- Maximum transverse stress 1800 psi

850A- FEA Analysis: Boat Lifting Points (B.L.P.)

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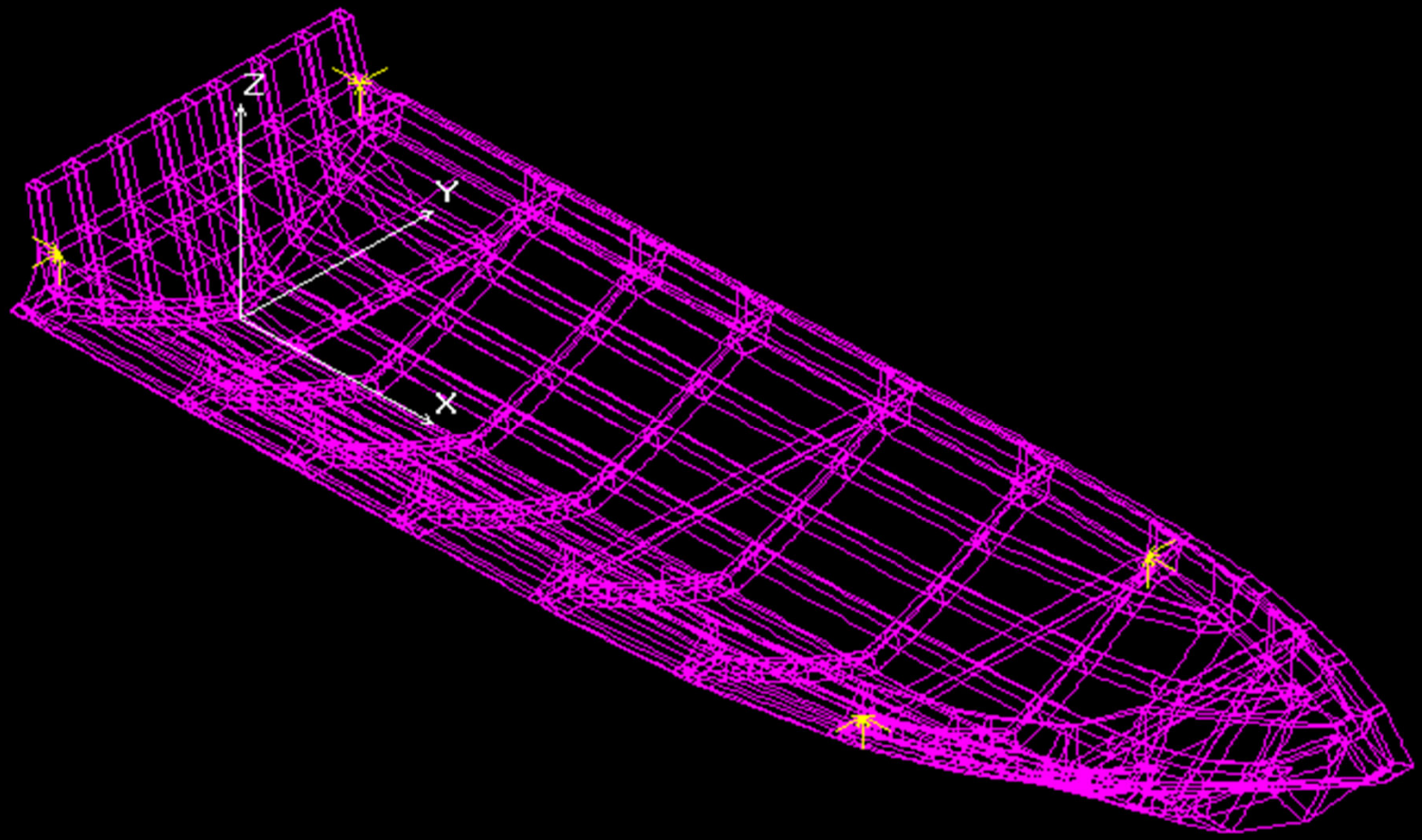
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
  - Redesigned to accommodate tube mounting.
  - Positioned for design LCG

LC8- BLP- Load Data

- Lift weight 7240, SF 6
- 4 point lift
- F_z all four lift points +10860 lbs
- F_x at aft two lift points +3430 lbs
- F_x at fwd two lift points -3430 lbs
- F_y at stbd two lift points +1300 lbs
- F_y at port two lift points -1300 lbs

LC8- BLP- Force Vector at Lift Points



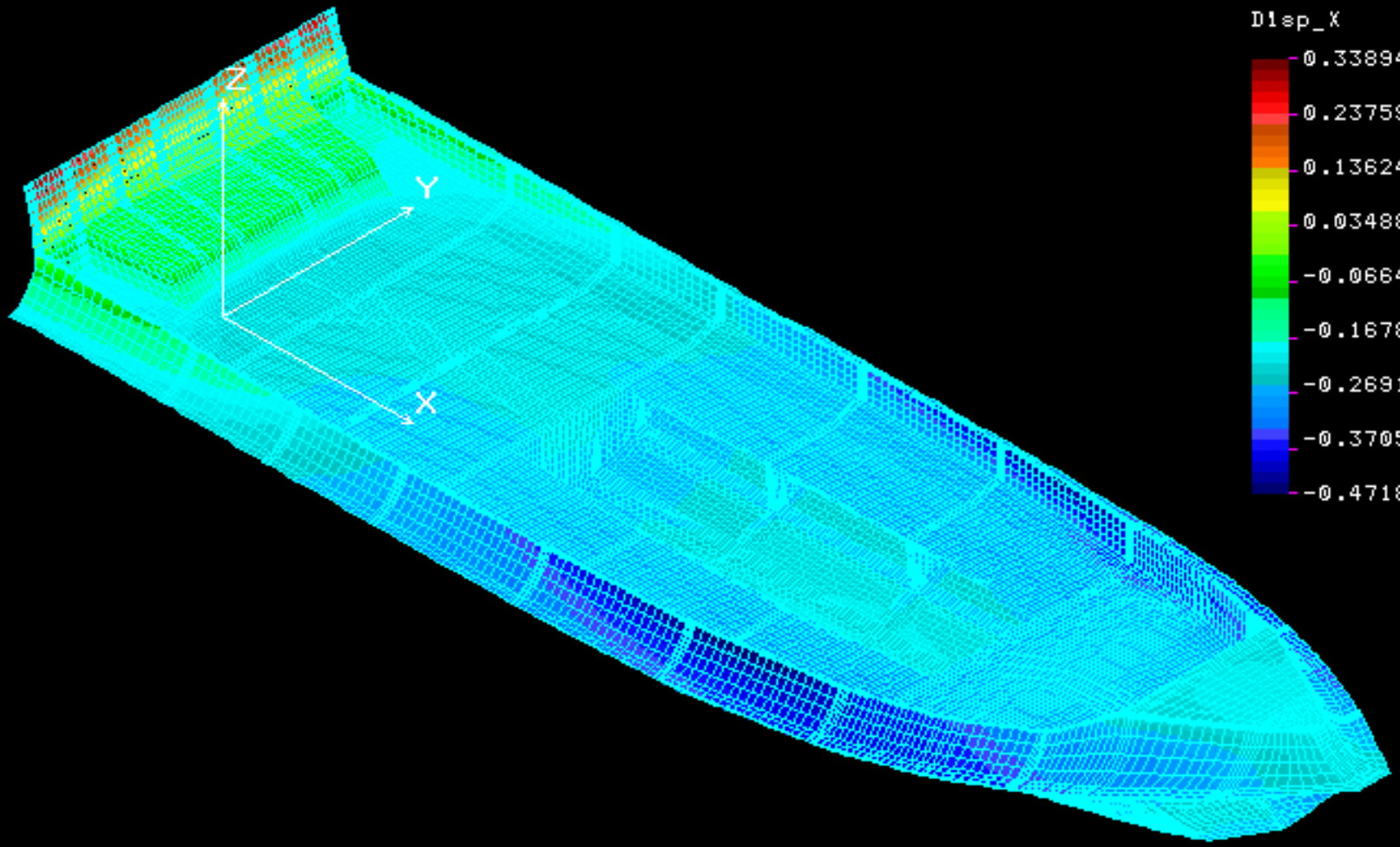
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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints F_r < 1 lb
- Thus constraints do not affect results

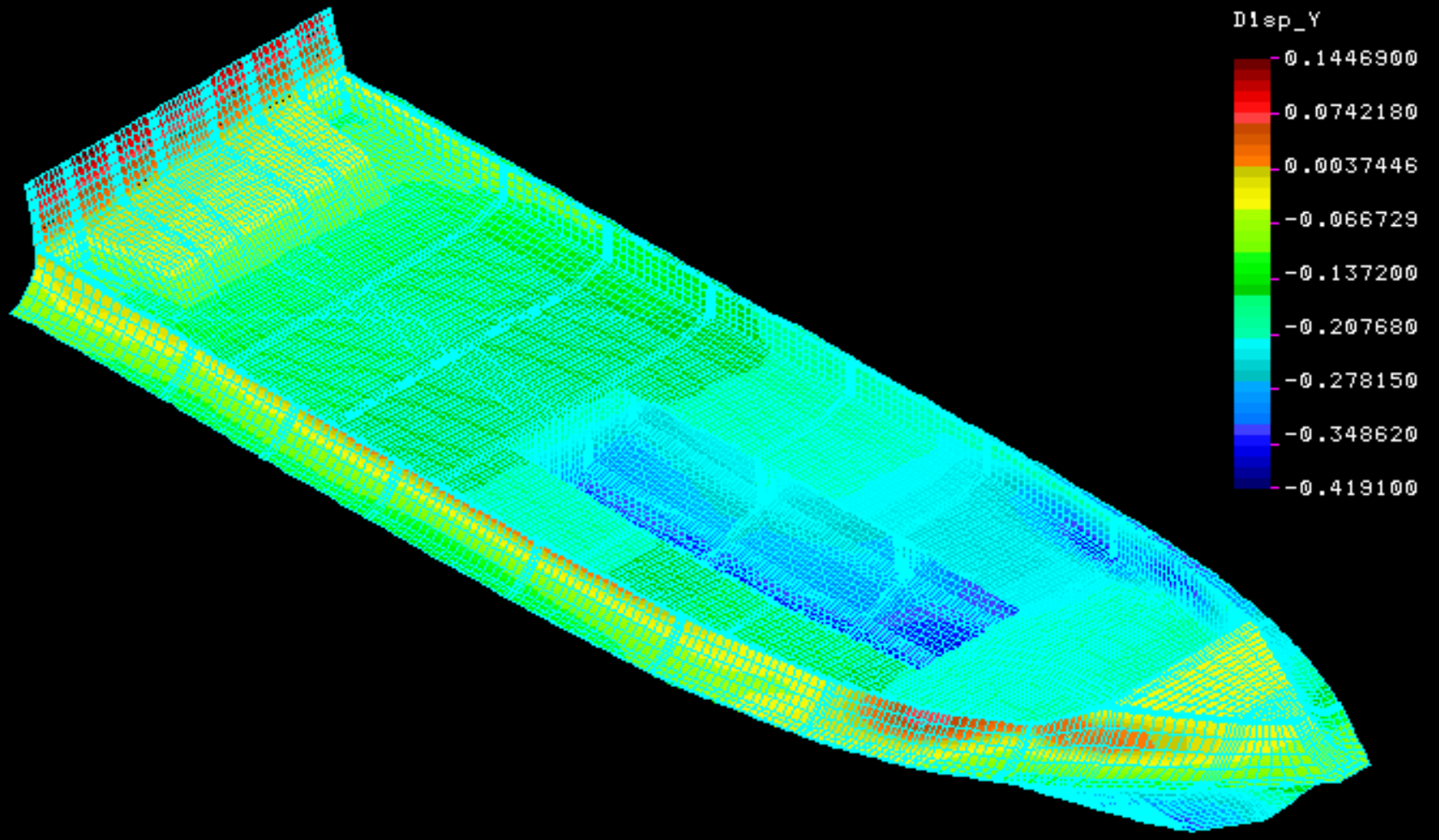
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LC8- BLP- X Displacement



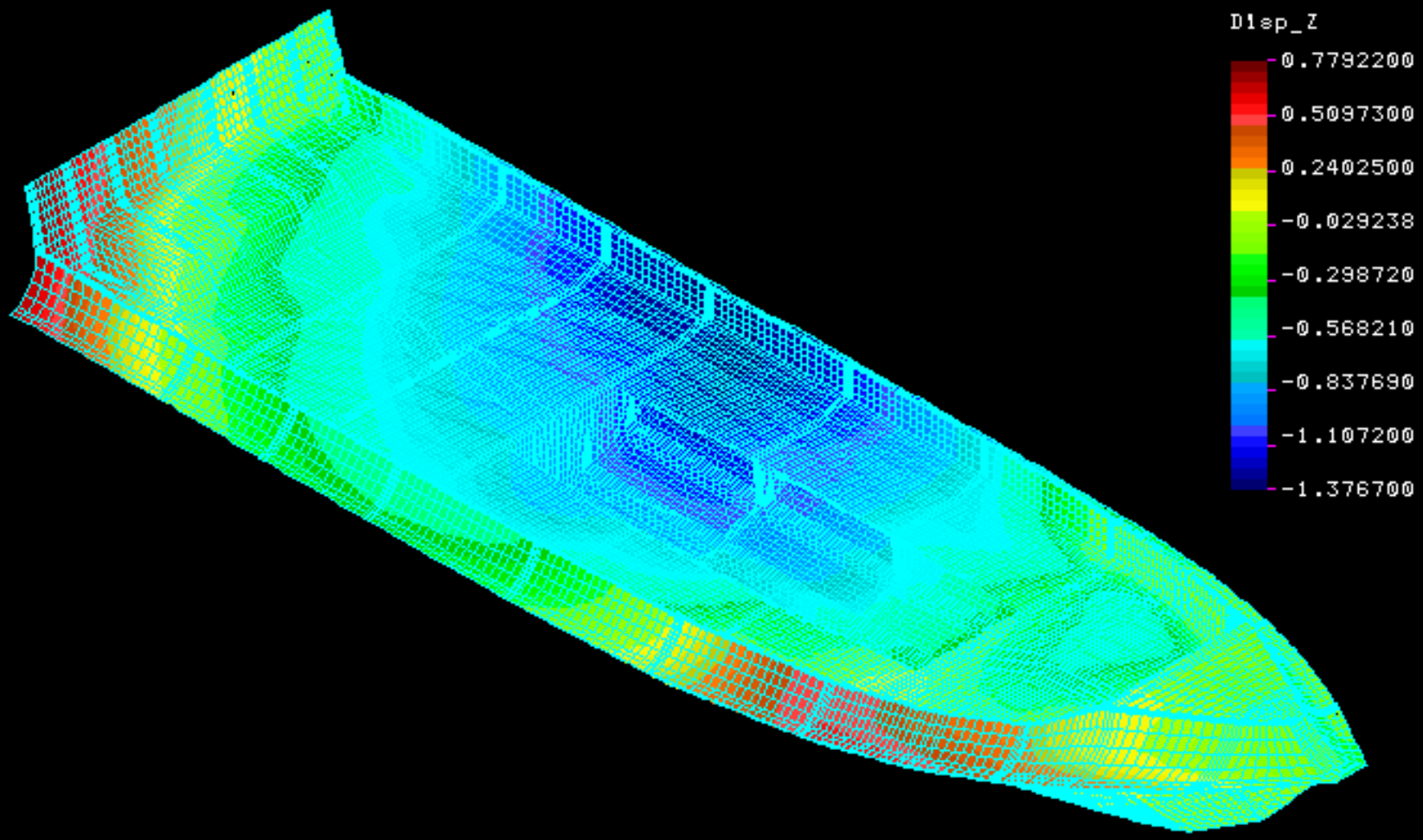
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LC8- BLP- Y Displacement



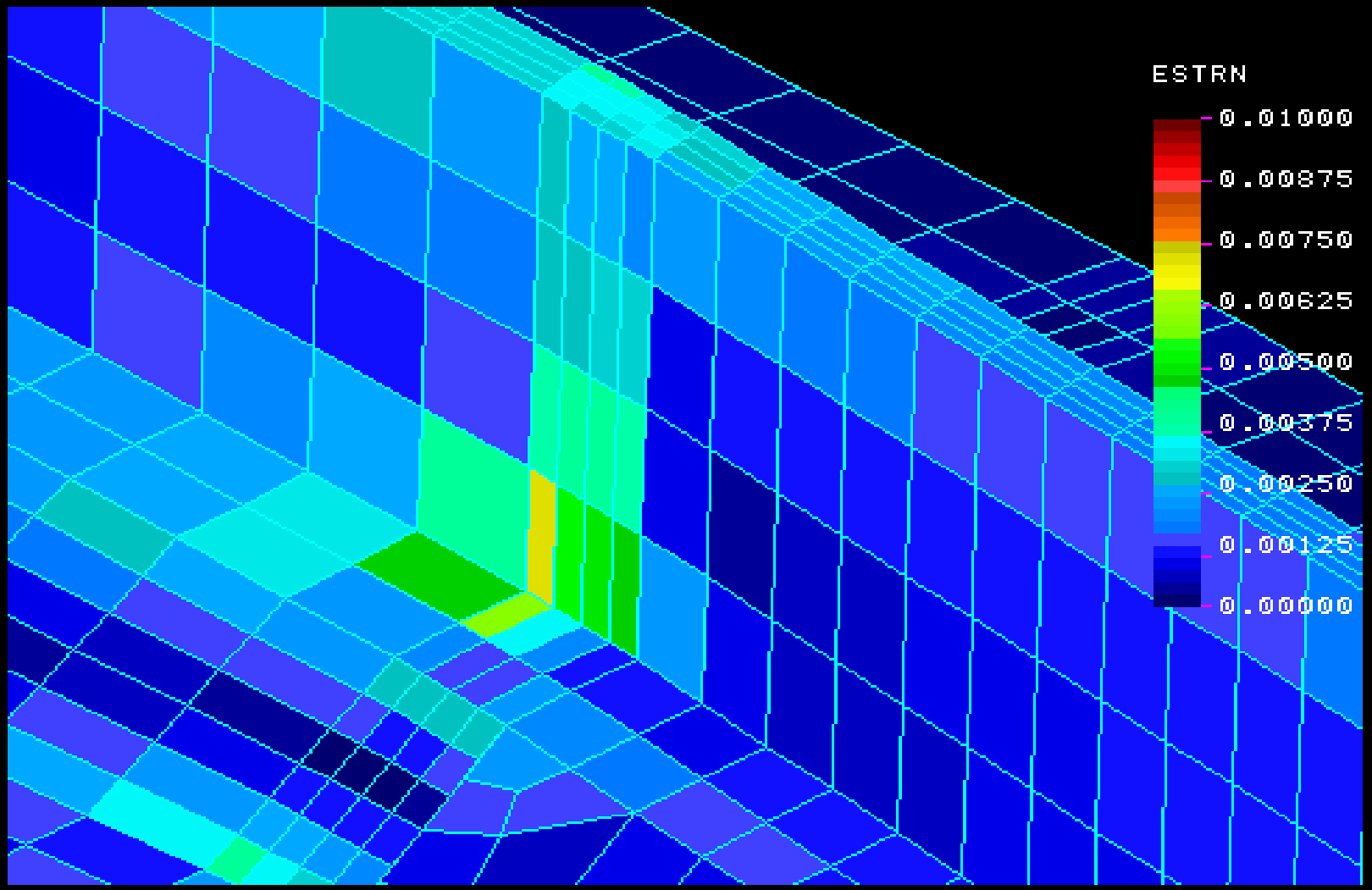
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LC8- BLP- Z Displacement



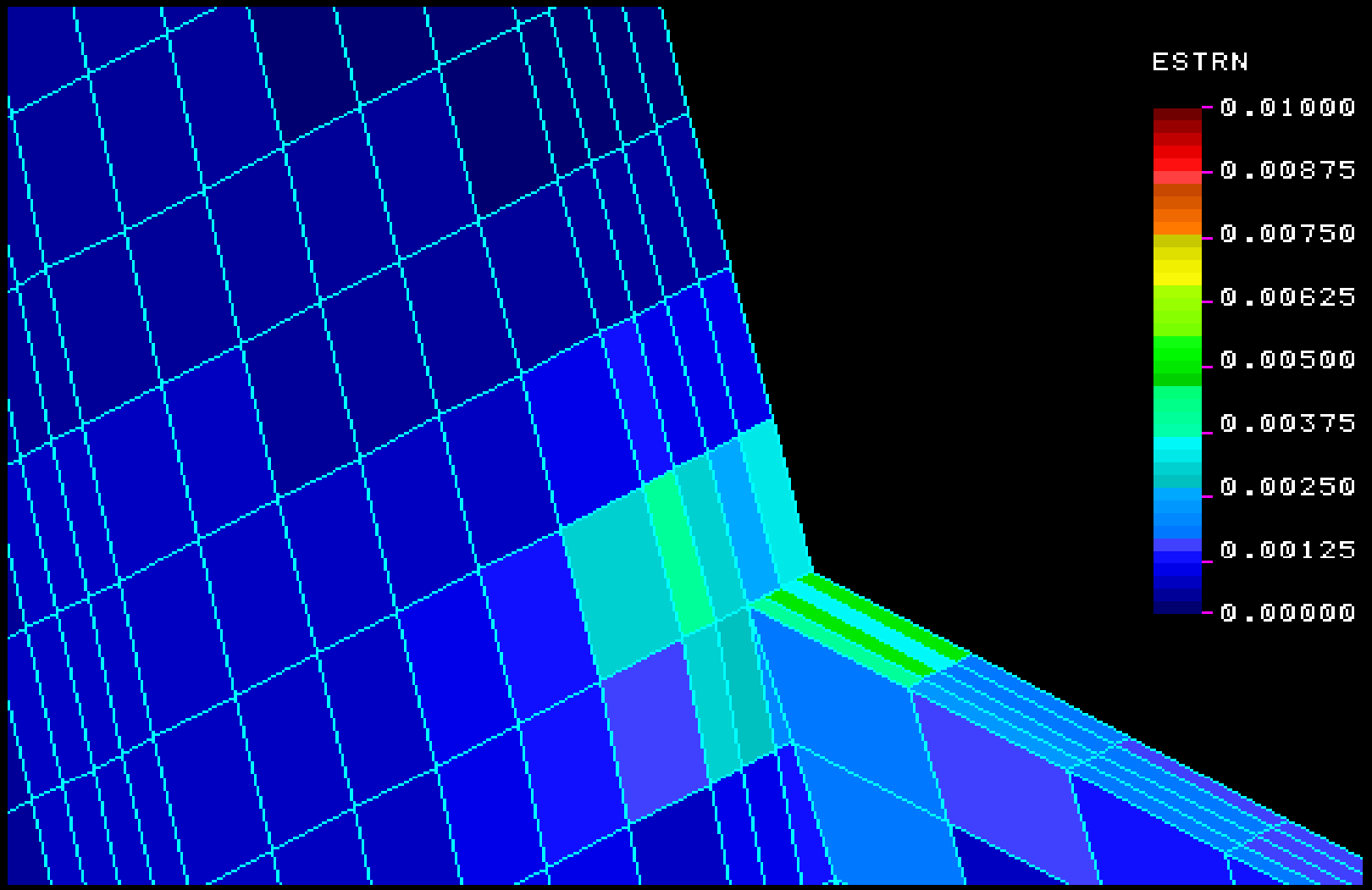
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LC8- BLP- Strain Fwd Lift Point



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LC8- BLP- Strain Aft Lift Point



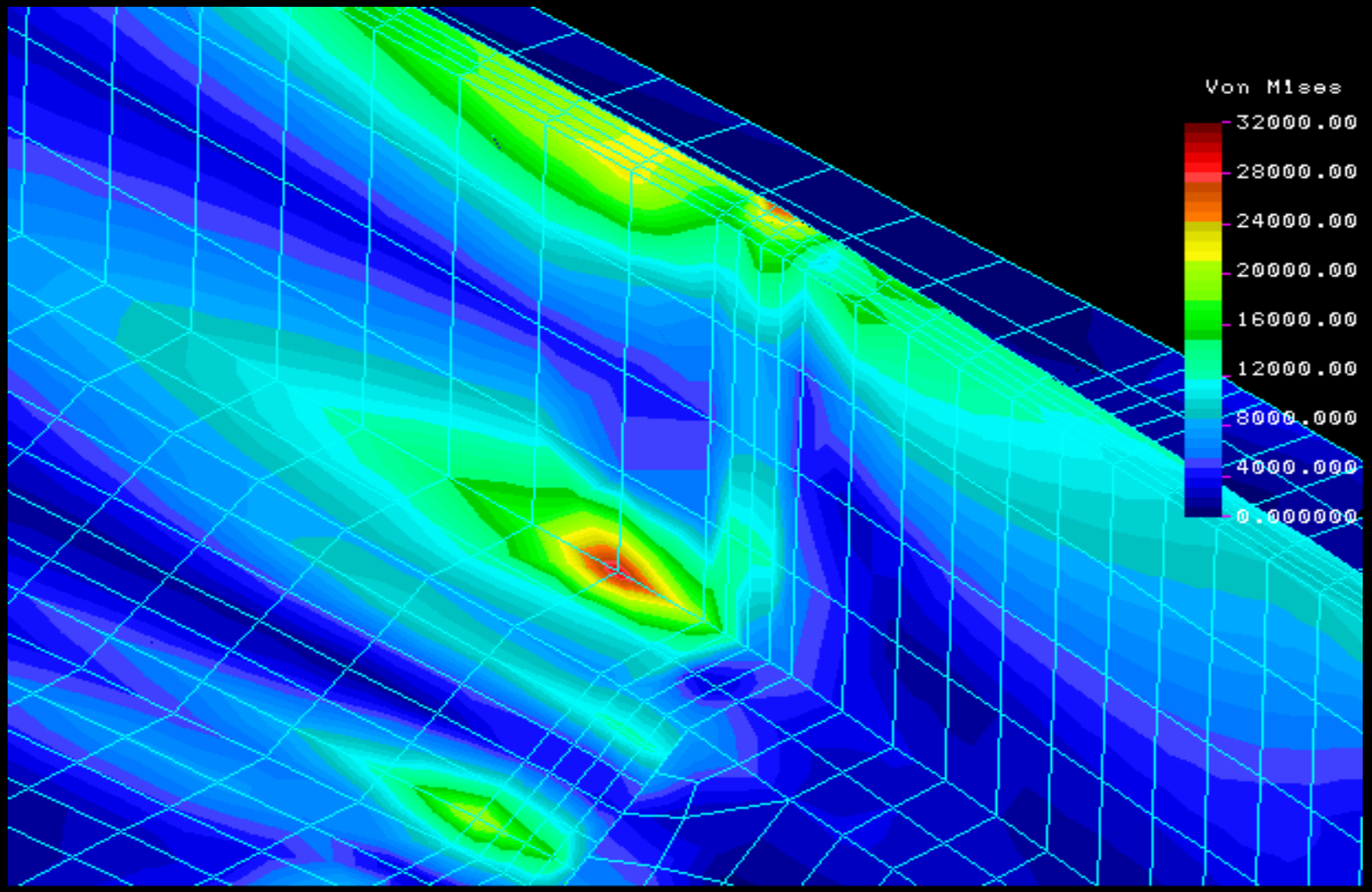
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LC8- BLP- Longitudinal Stress Fwd Lift Point



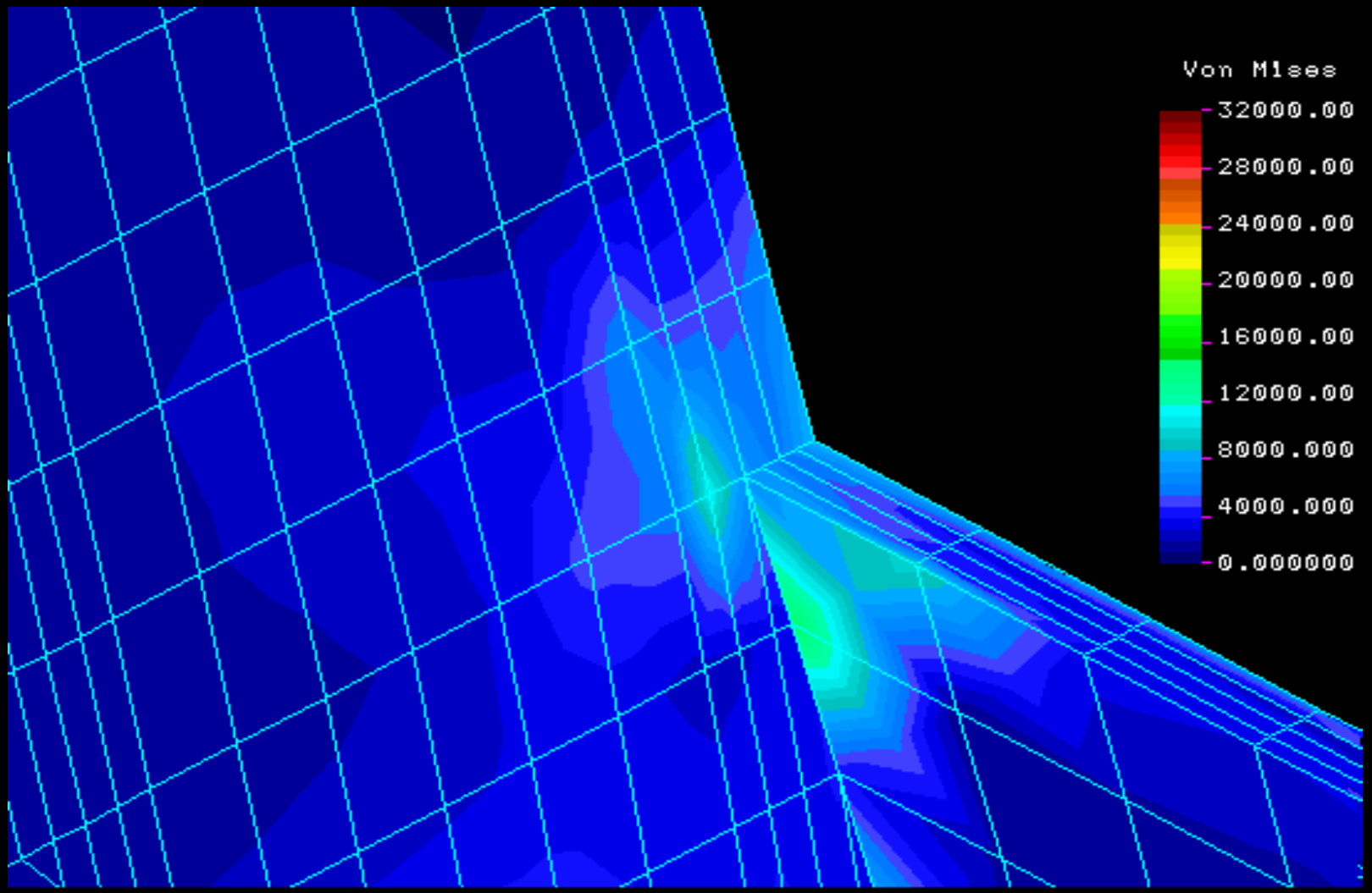
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LC8- BLP- Longitudinal Stress Aft Lift Point



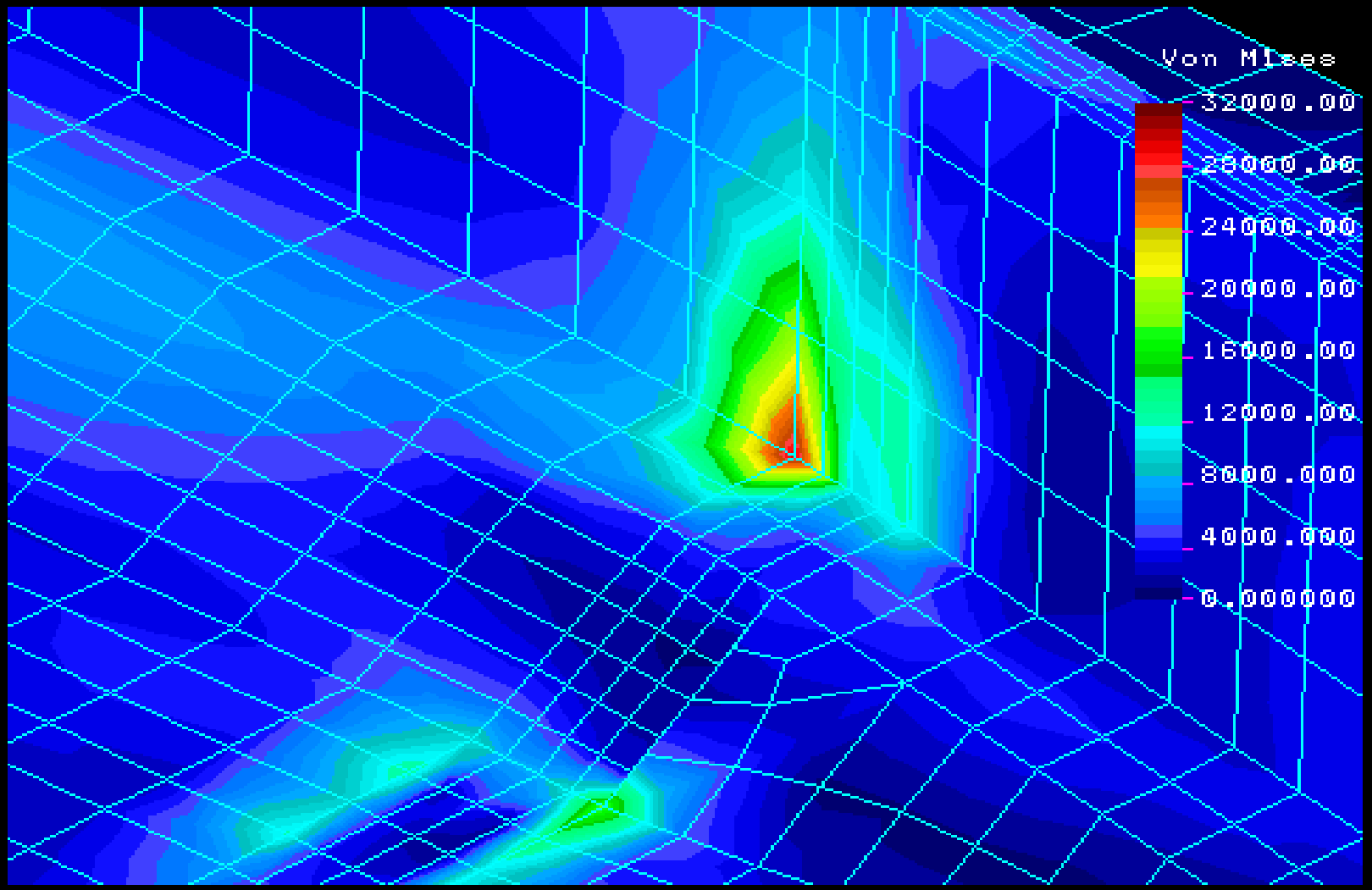
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LC8- BLP- Transverse Stress Fwd Lift Point



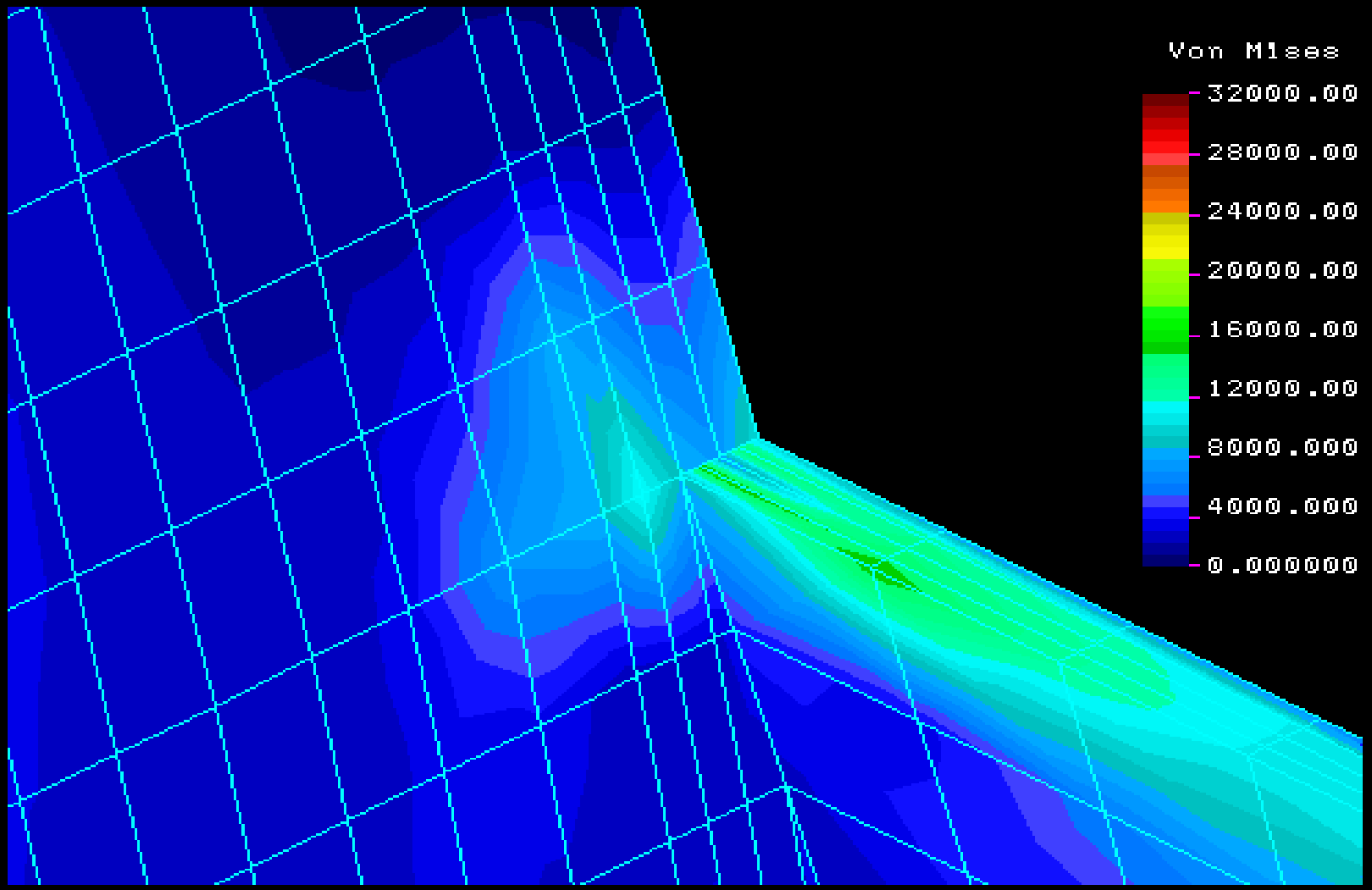
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LC8- BLP- Transverse Stress Aft Lift Point



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LC8- BLP- Lift Analysis Summary

- Model shows structure is adequate for this load case
- FOS: 6
- Range of deflection 1.7 in.
- Maximum strain at lift points 0.0067 in/in
- Maximum longitudinal stress 20,000 psi
- Maximum transverse stress 24,500 psi

850A- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

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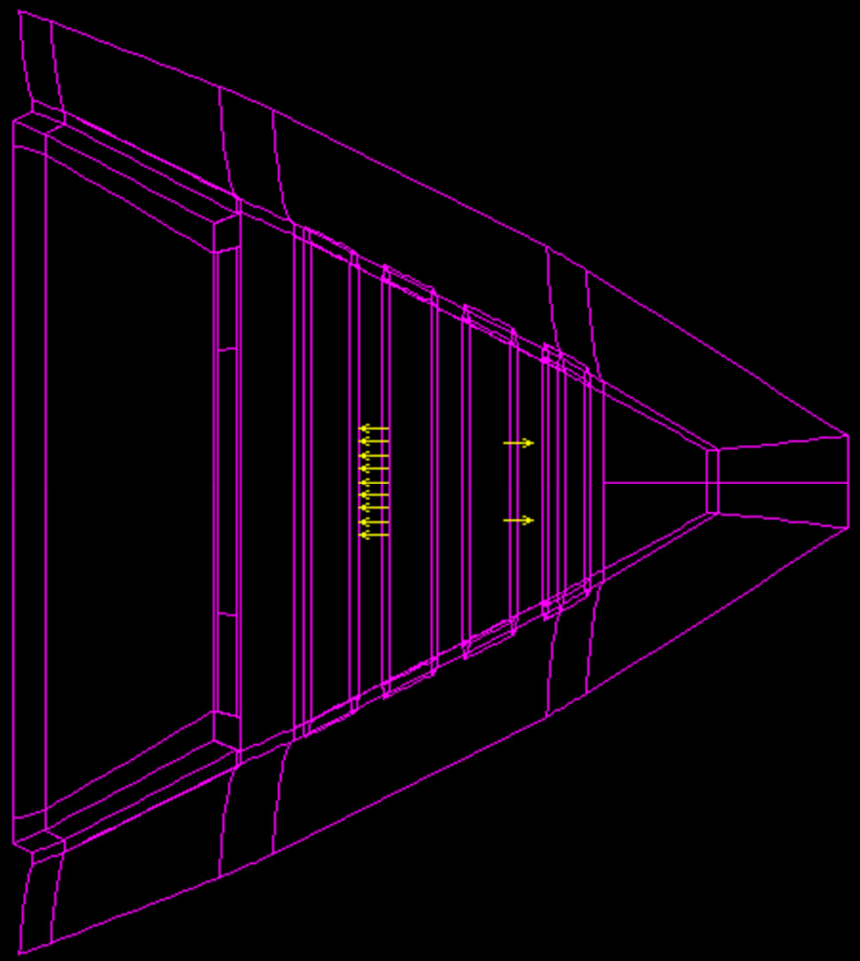
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Gun Mount Framing Notes

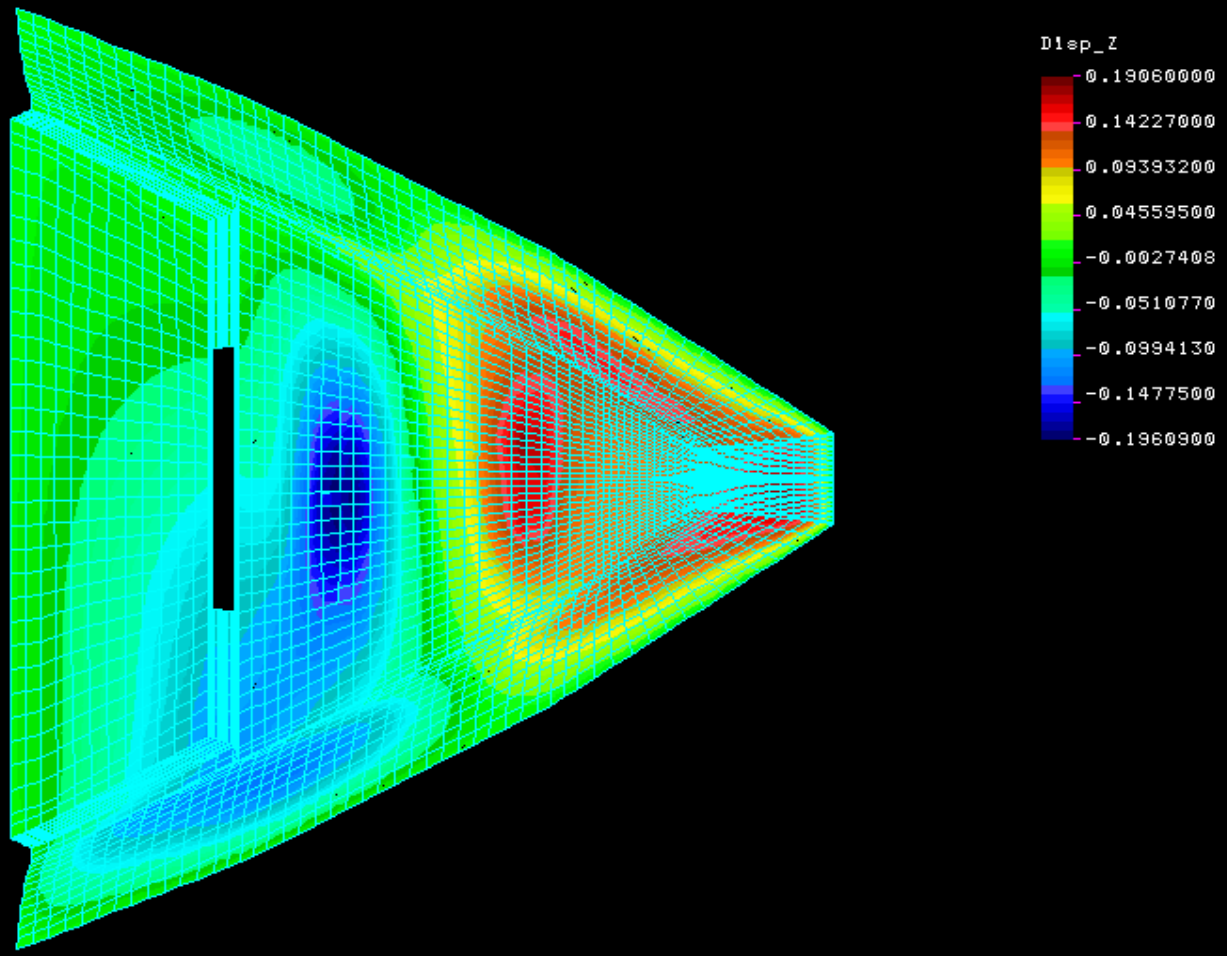
- Four transverse frames, TR3030X, are placed on five inch centers
- Skin laminate is four layers of 3610
- Frame laminate:
  - 24 oz (+/-45) on PRISMA Beam
  - 4 layers 1810 warp uni
  - 2408 (+/-45) cover fabric

LC9- GML- Long. Loading



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LC9- GML- Z Displacement



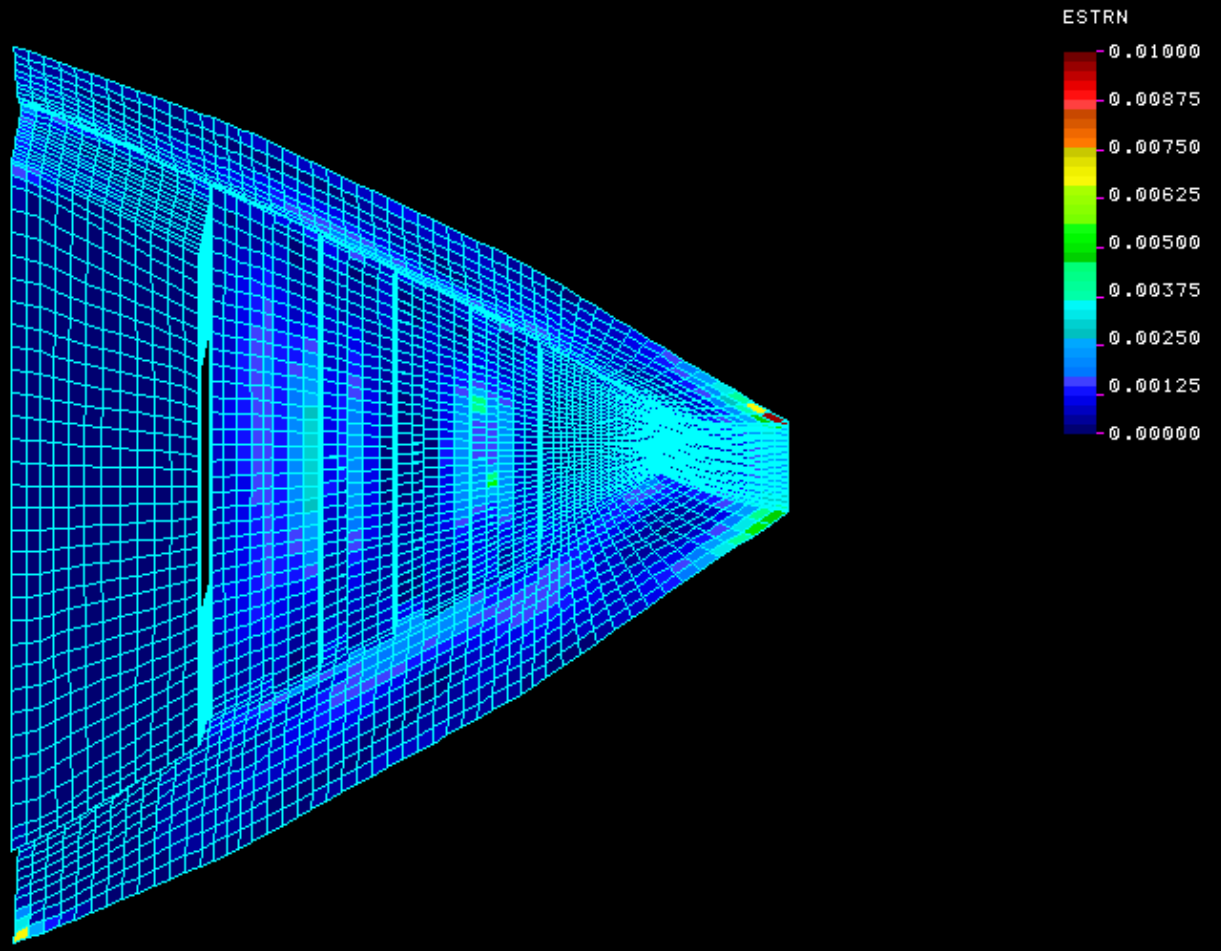
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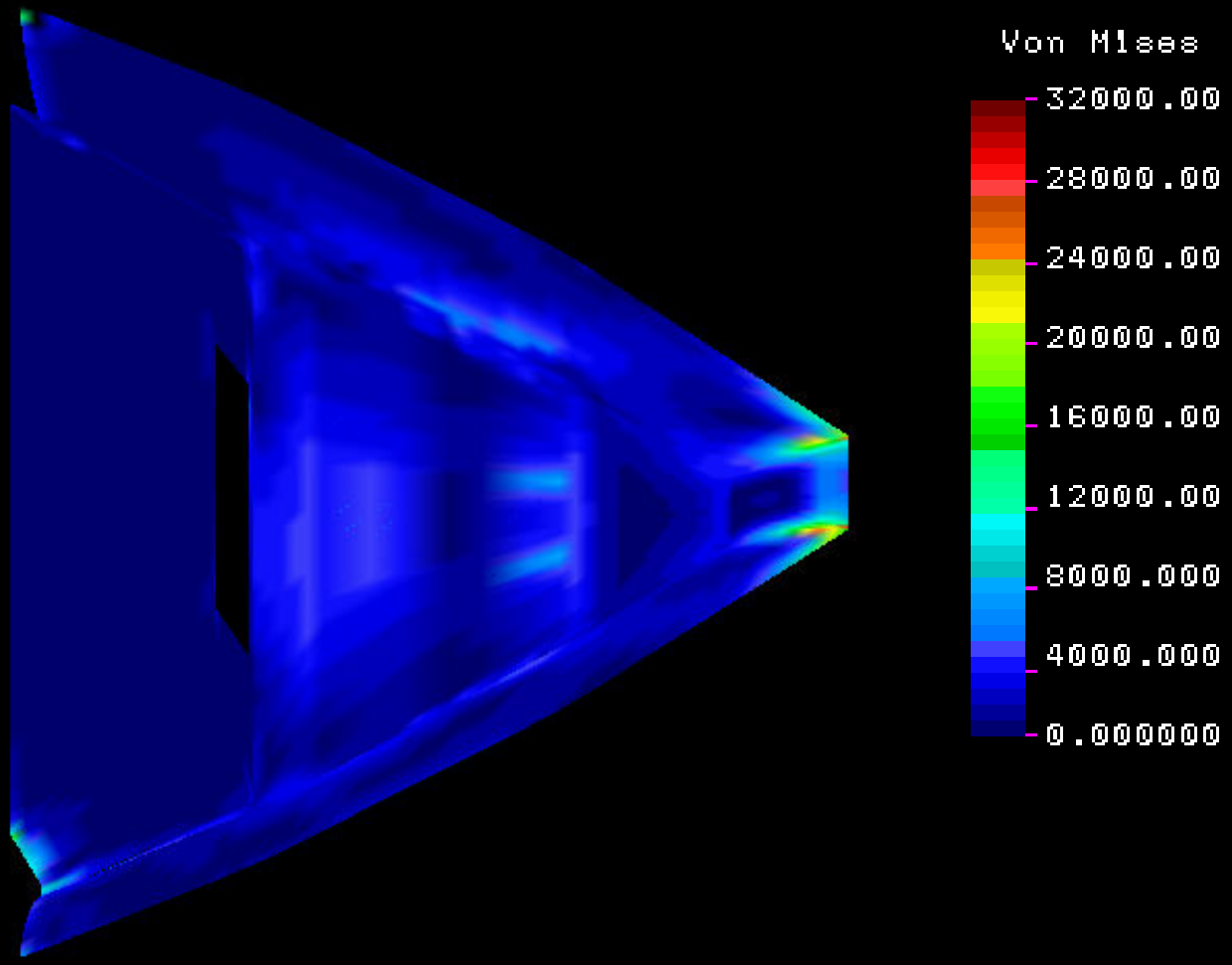
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LC9- GML- Strain (Bottom View)



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LC9- GML- Stress in Long. Ply (Top)



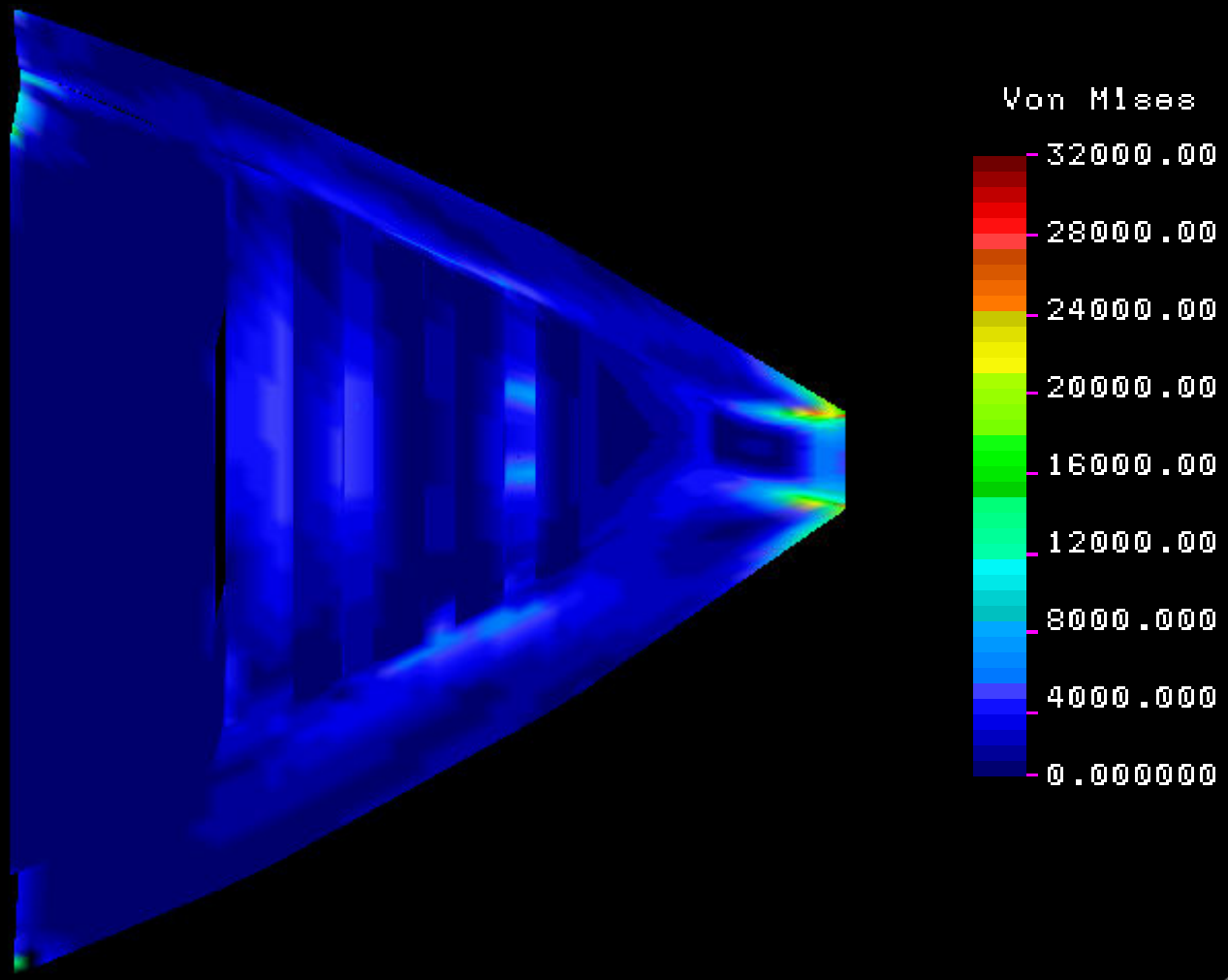
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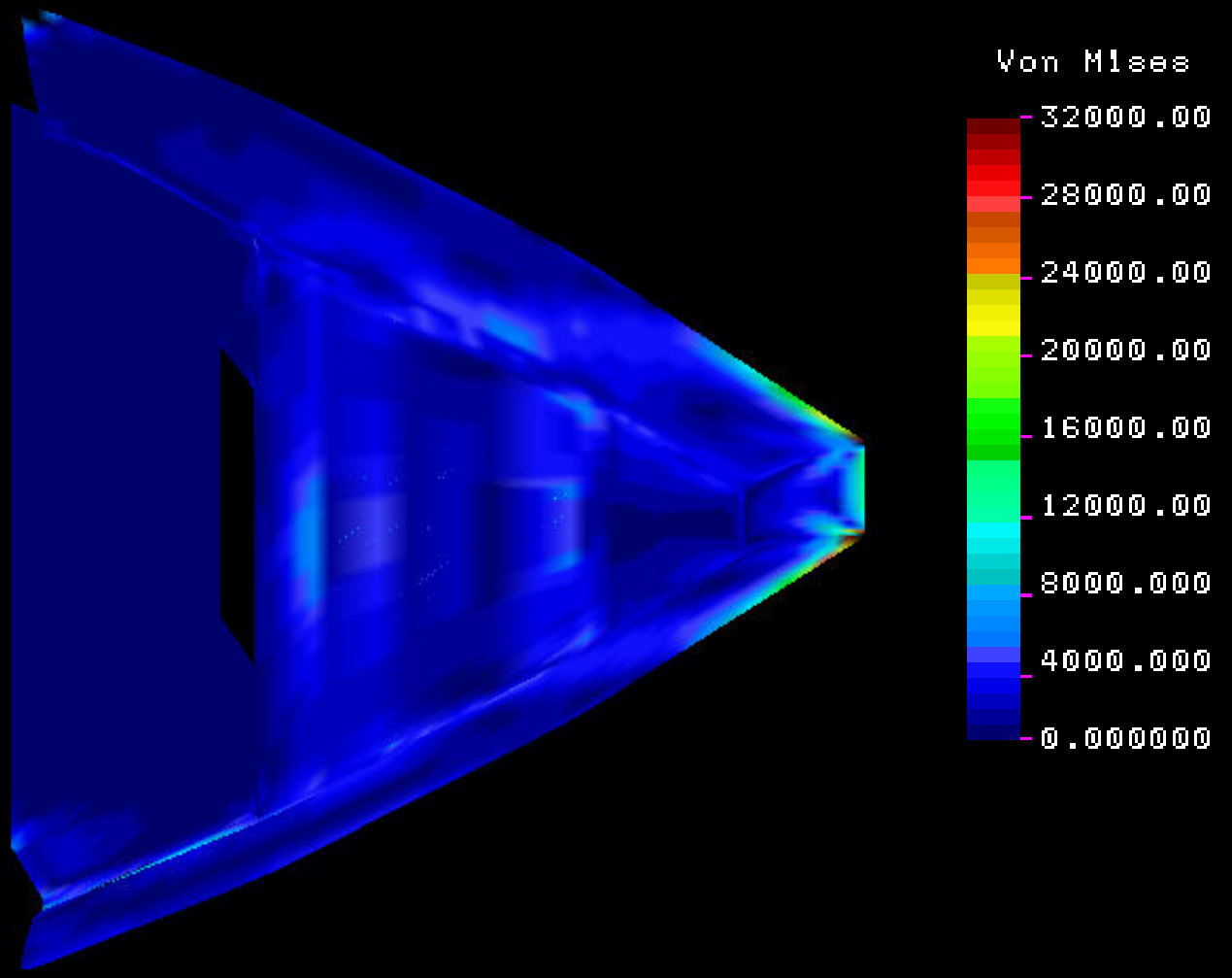
ZODIAC®

LC9- GML- Stress in Long. Ply (Bottom)



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LC9- GML- Stress in Tran. Ply (Top)



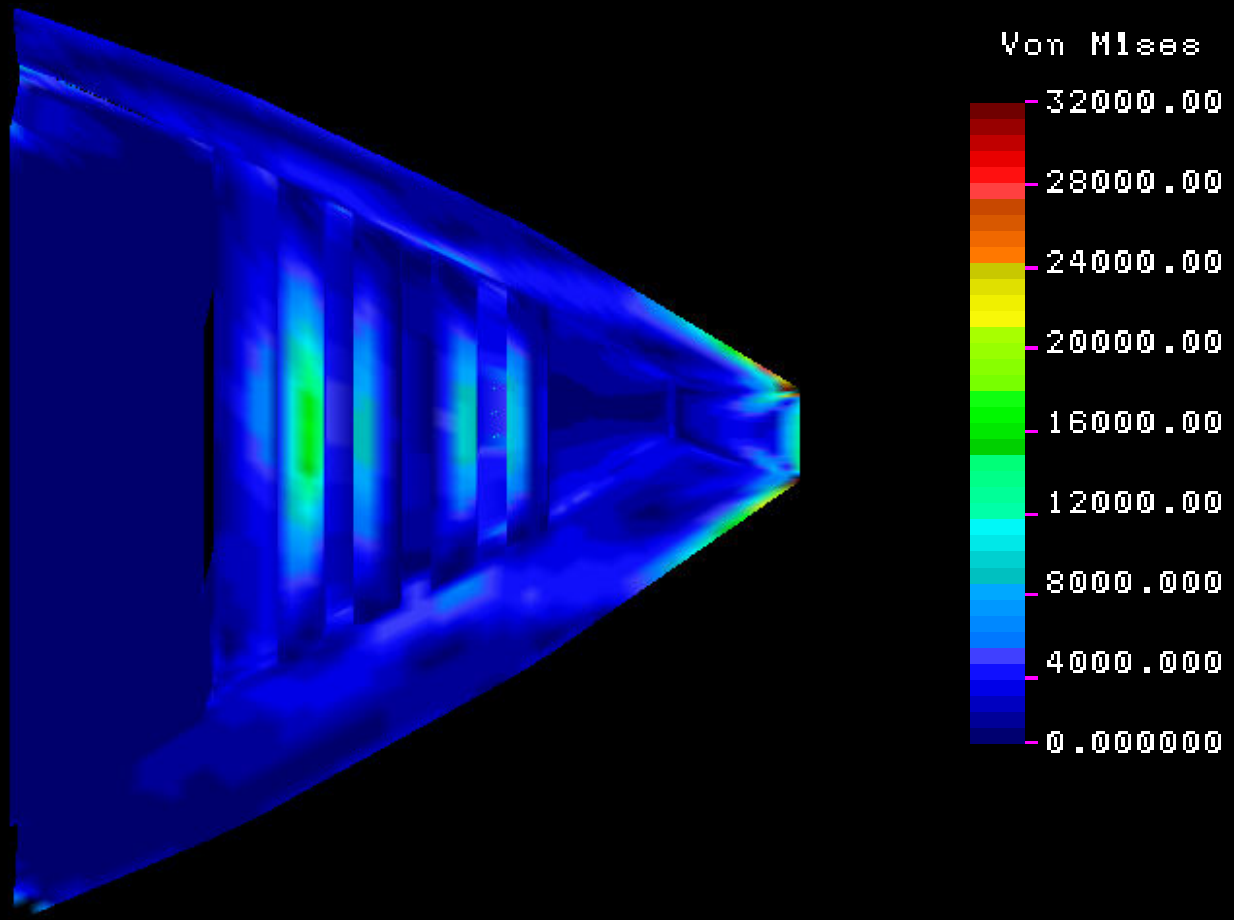
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LC9- GML- Stress in Tran. Ply (Bottom)



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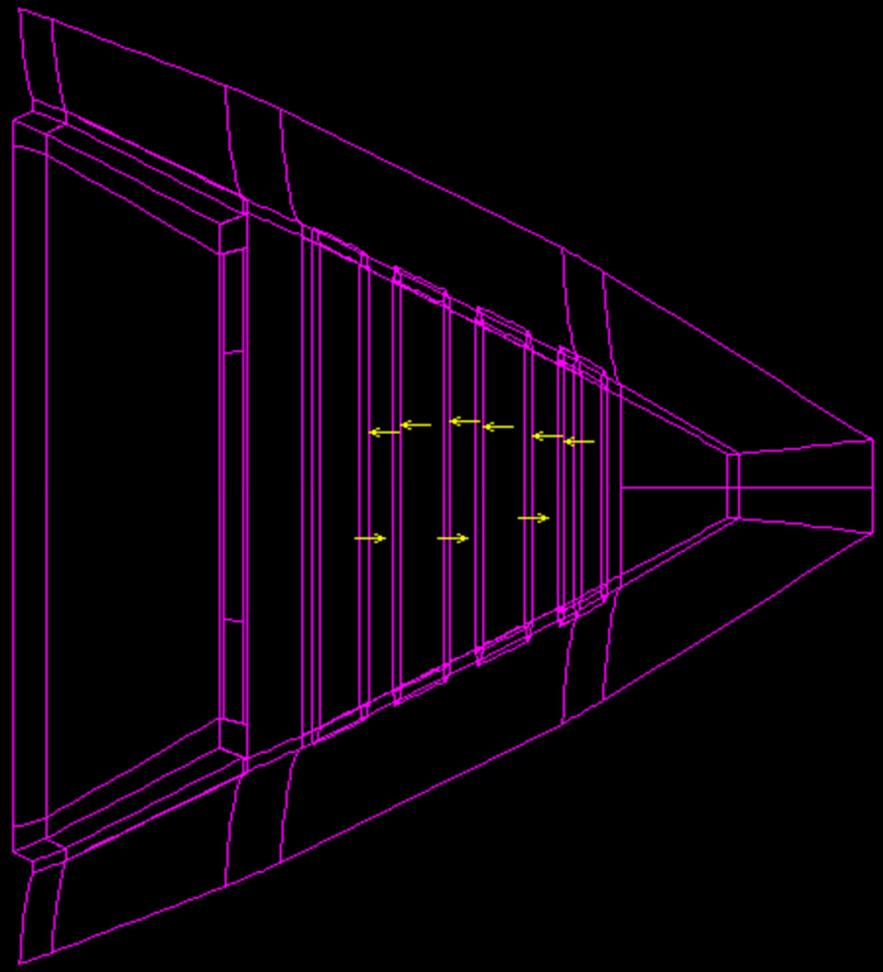
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850A- G.M.L- Summary

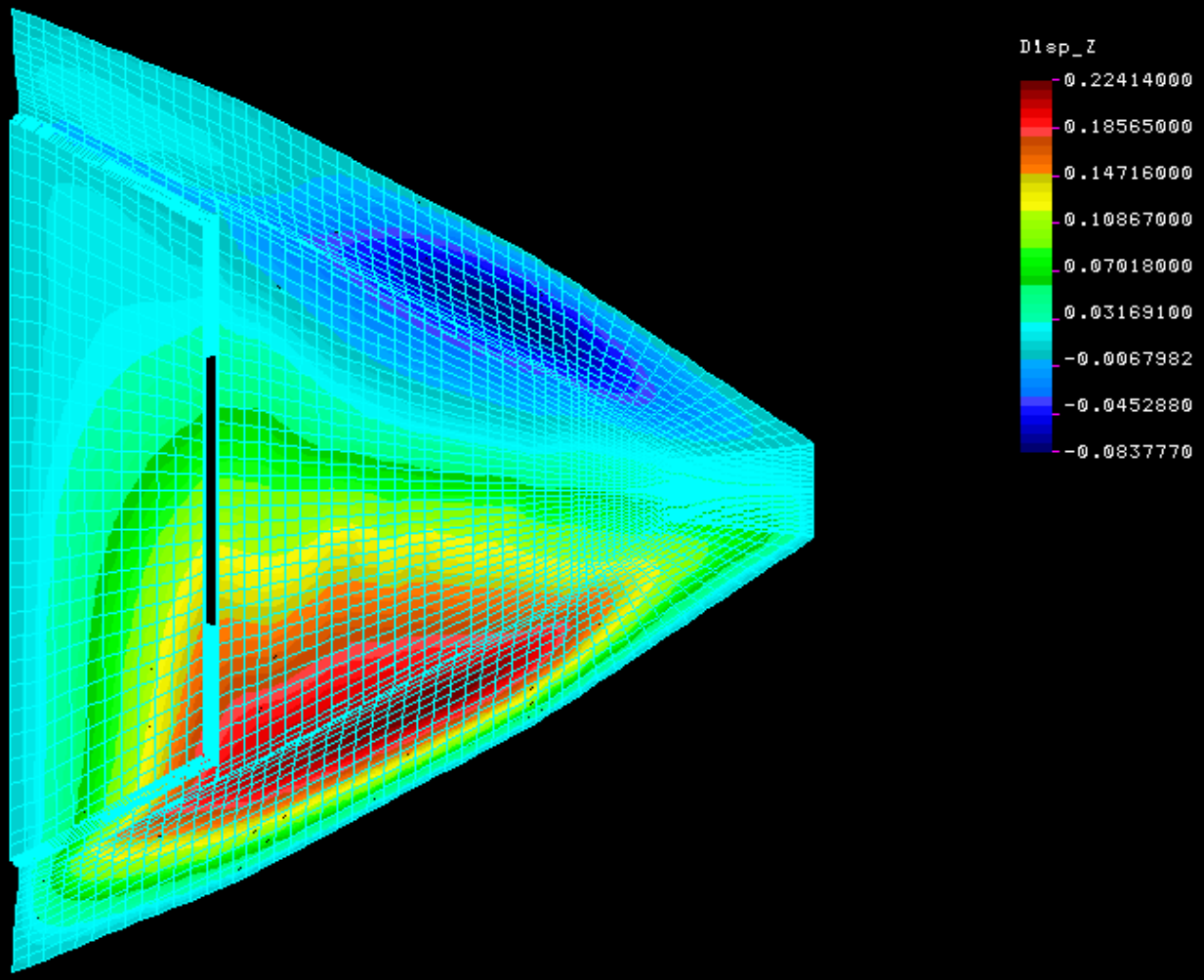
- Range of deflection 0.29 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 15,500 psi

LC10- GMT- Trans. Loading



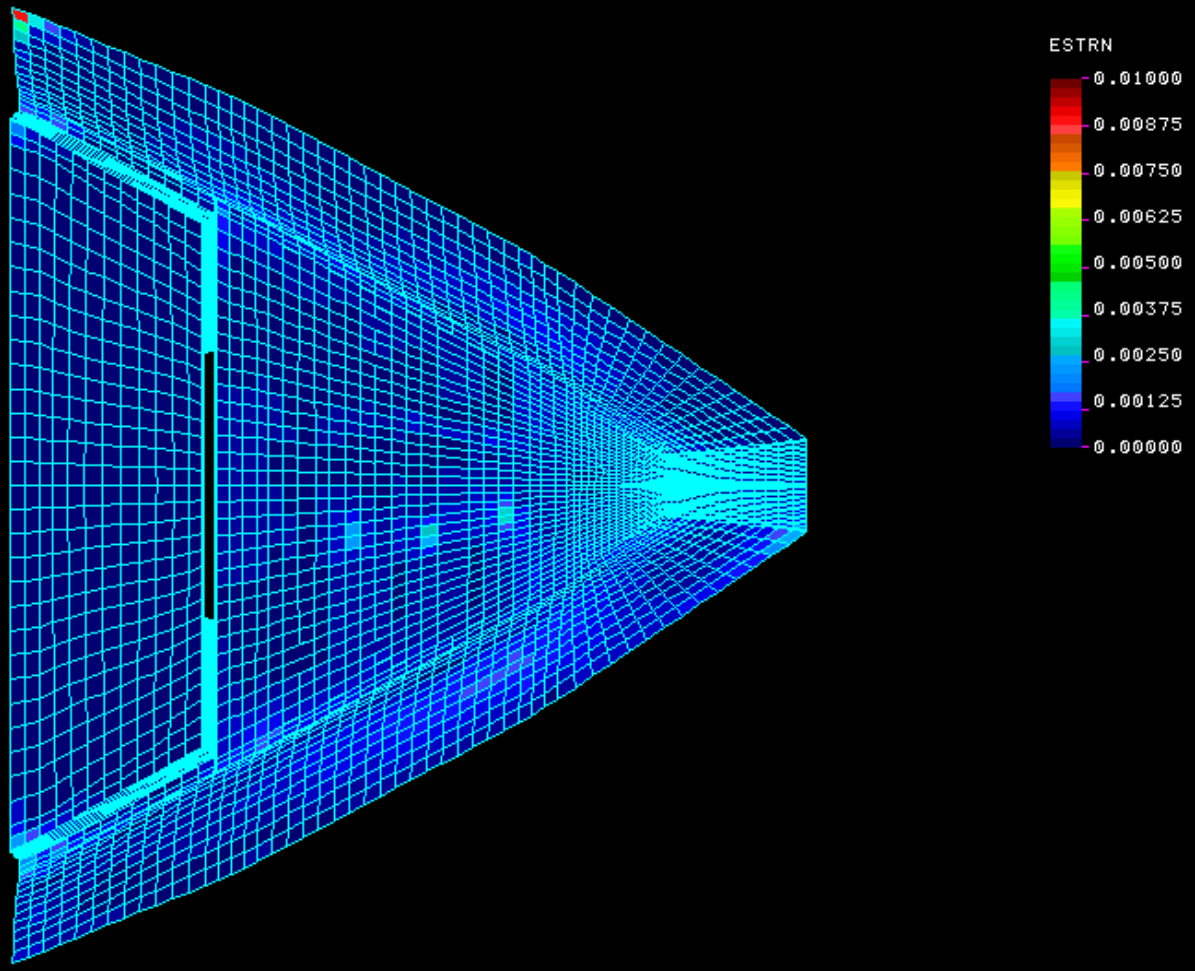
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LC10- GMT- Z Displacement



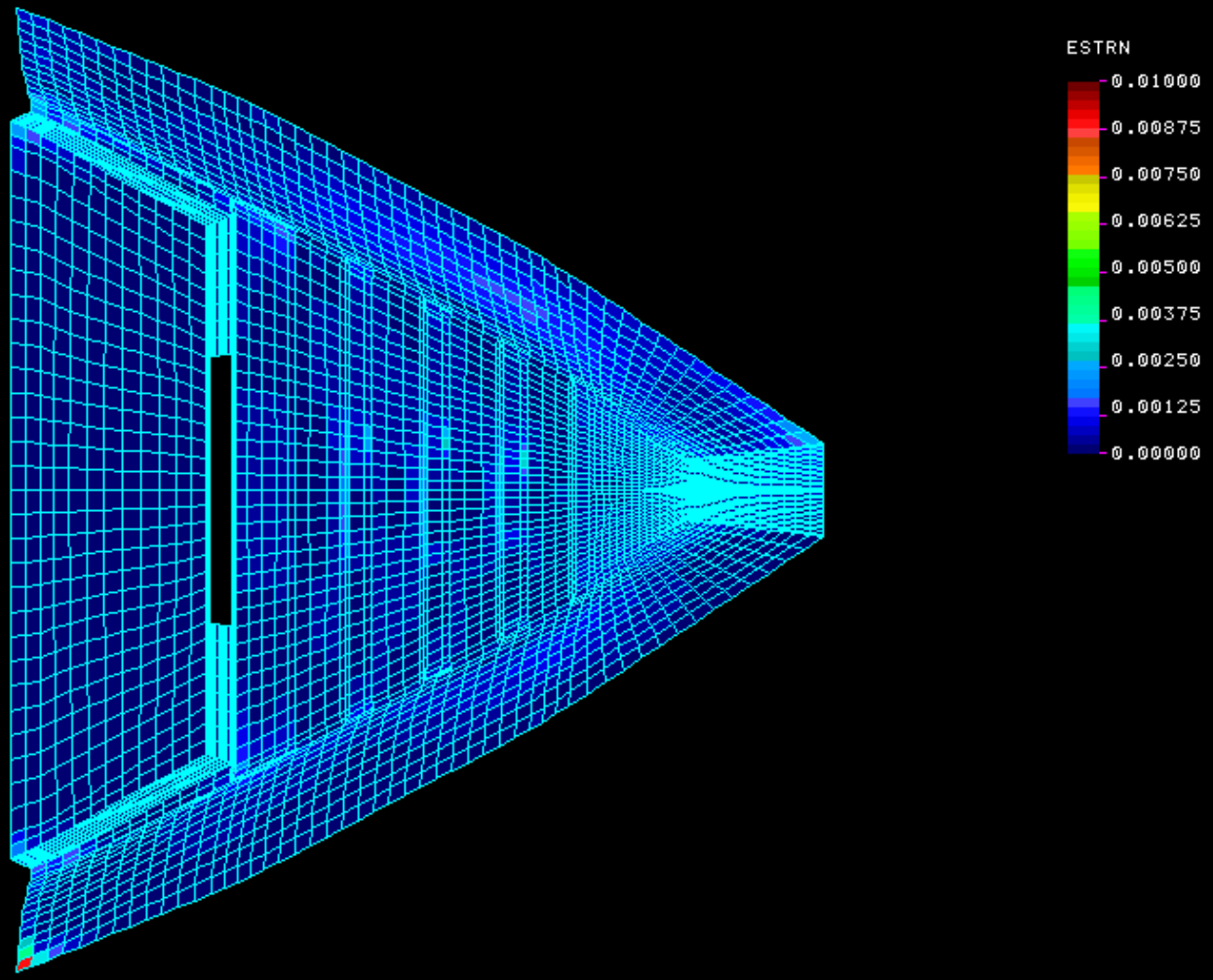
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LC10- GMT- Strain (Top View)



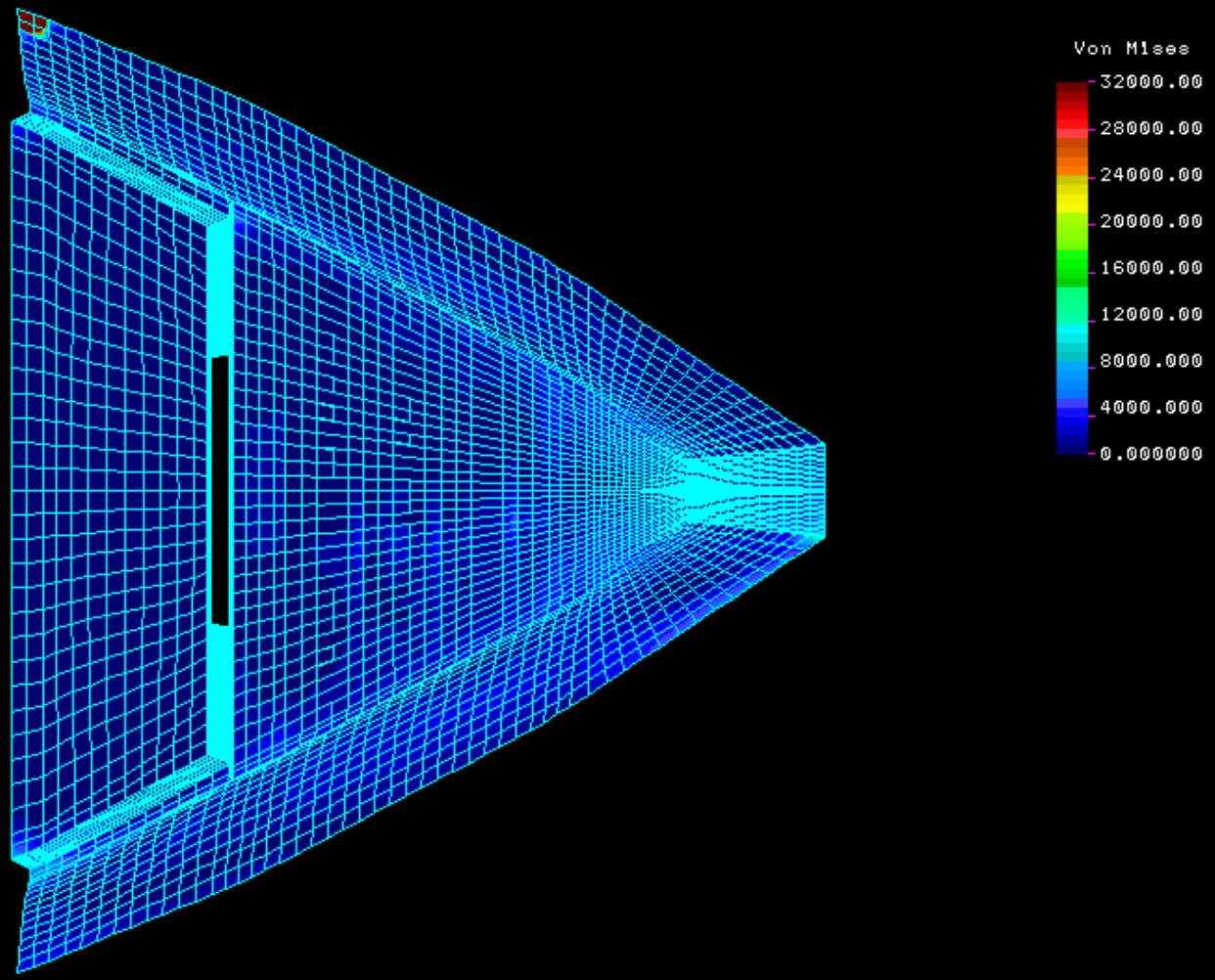
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LC10- GMT- Strain (Bottom View)



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LC10- GMT- Stress in Longitudinal Ply (Top)



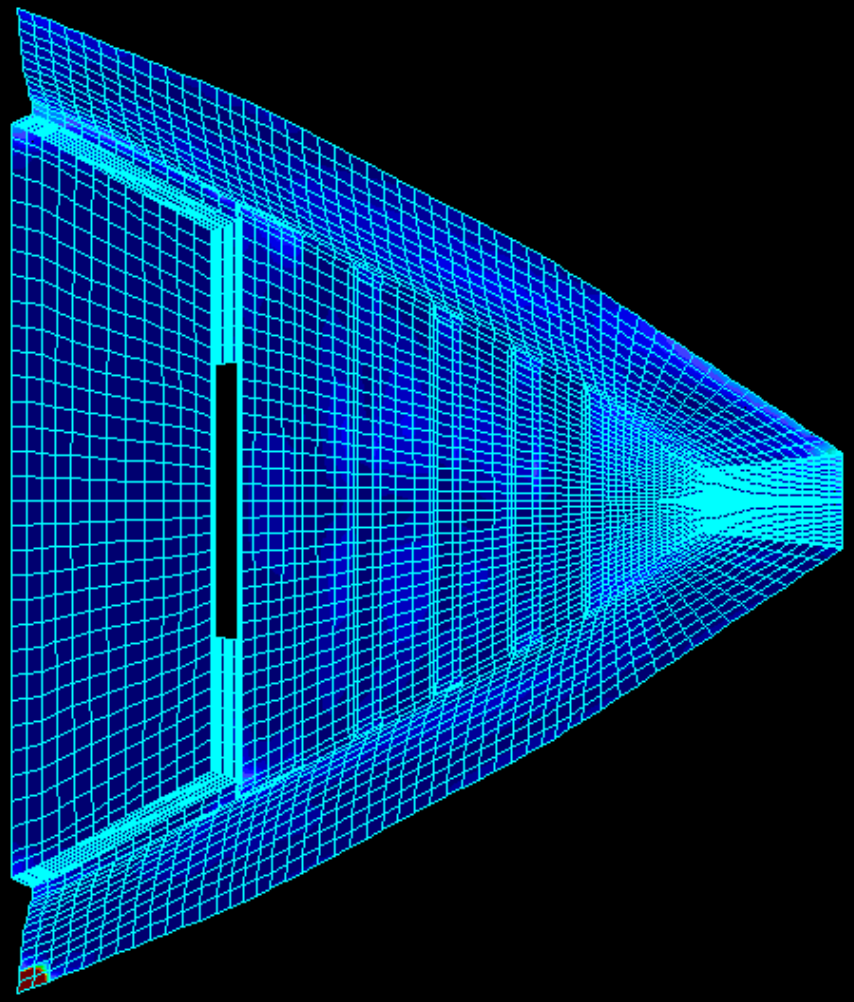
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LC10- GMT- Stress in Long. Ply (Bottom)



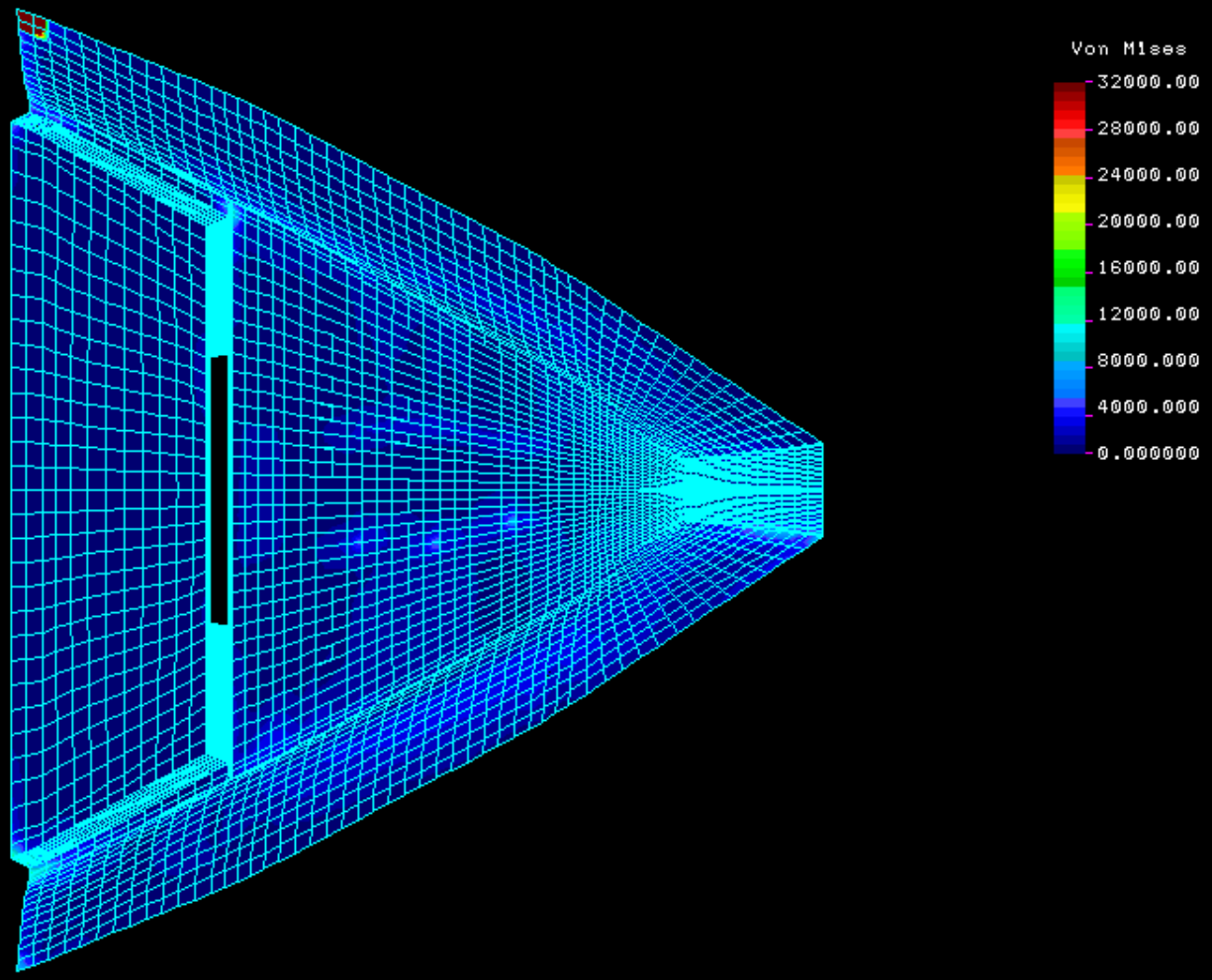
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LC10- GMT- Stress in Tran. Ply (Top)



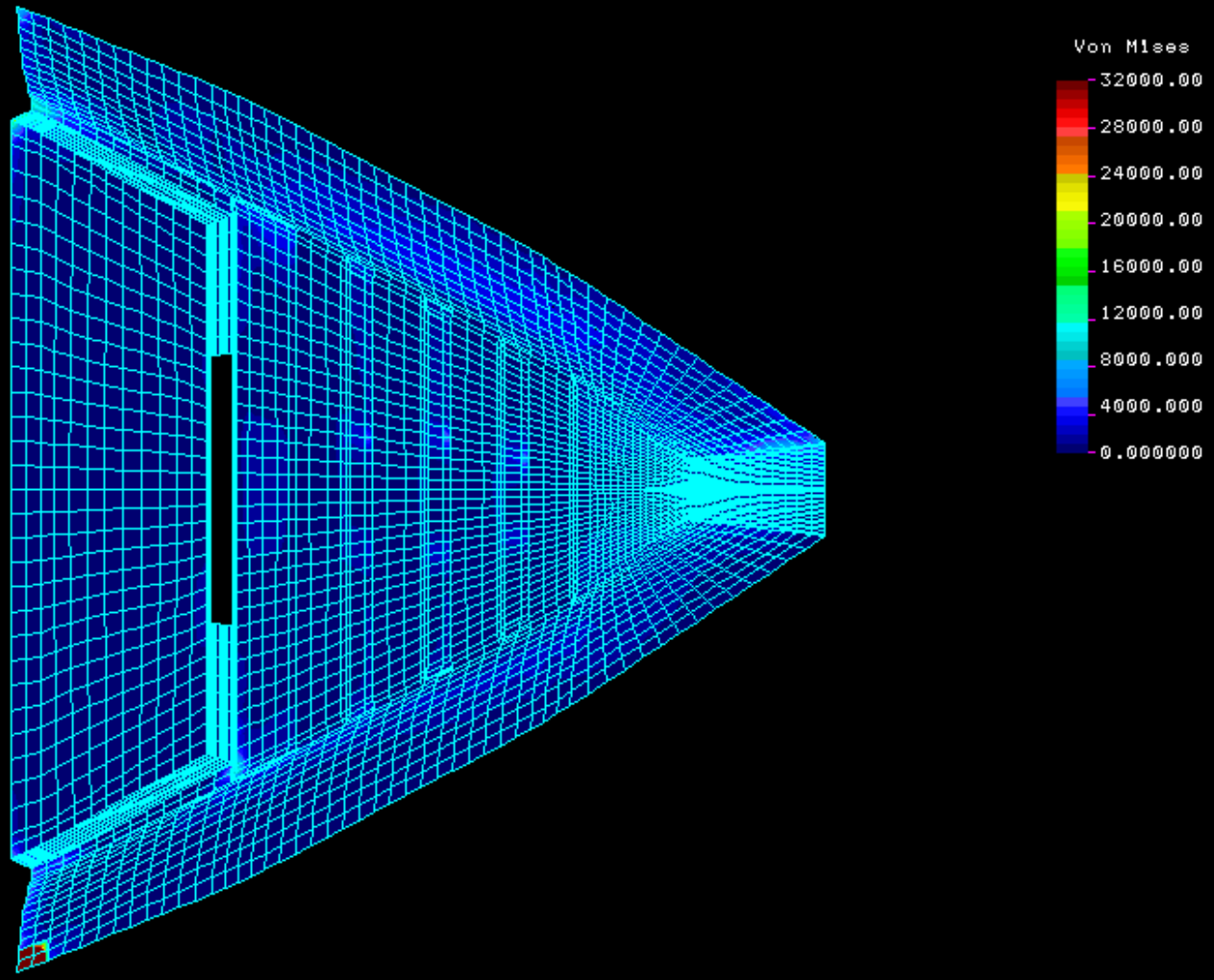
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LC10- GMT- Stress in Tran. Ply (Bottom)



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850A- G.M.T- Summary

- Range of deflection 0.25 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 5,000 psi

Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
  - Slight weight increase from Rev 0
- FOS for strength in excess of 10

Lightweight Shock Mitigation in Naval RIB Hull Structures

SCRA Subcontract #2011-510











850 B FINAL DESIGN REVIEW
July 2011

IBIF 850 Design Presentation

- Contents
  - 850 B Design Presentation
  - Weight Estimates 850 B, 850 A
  - 850B Drawings Package
  - 850B FEA Load Cases

850B Design Presentation

- 850 B Drawing Package
  - Hull
  - Deck
  - Hatches
  - Console
- 850 B Structural Analysis
  - Wave Load FEA
  - Calm Water FEA
  - Gun Mount FEA
  - Lift Load FEA
  - Single Skin Transom FEA

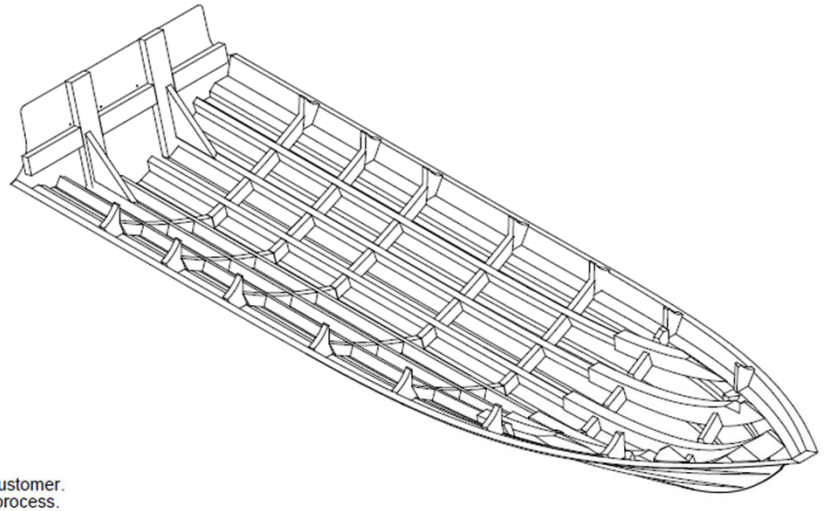
850B- Hull Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/-45 fabric
9	A/R	E-LTBXM 1208 Quad fabric	Vectorply		
10	A/R	E-LM 1810 fabric 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
11		not used			
12		not used			
13		not used			
14	140 LF	TR4030X	Compsys	TR4030X	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850IMB-SFOS	
16	1	Starboard Mid Stringer	Compsys	BCG850IMB-SFMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850IMB-SFIS	
18	1	Port Outboard Stringer	Compsys	BCG850IMB-PFOS	
19	1	Port Mid Stringer	Compsys	BCG850IMB-PFMS	
20	1	Port Inboard Stringer	Compsys	BCG850IMB-PFIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	6 LF	TR8026 with 36oz double Bias	Compsys	TR8026	
26	7 LF	TR8026 with 36oz double Bias	Compsys	TR8026	
27	8	Bulkhead Wings - Bkhds C-G (P&S)	Compsys	BCG850IMB-P/SDS1-5	
28	1	Bulkhead Wing - Bkhds B (P)	Compsys	BCG850IMB-DS6	
29	1	Bulkhead Wing - Bkhds B (S)	Compsys	BCG850IMB-DS6	
30	1	Bulkhead Wing - Bkhds A (P)	Compsys	BCG850IMB-DS7	
31	1	Bulkhead Wing - Bkhds A (S)	Compsys	BCG850IMB-DS7	
32	1	FS2010	Compsys	FS2010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	
	B	TRANSOM KNEES	08/18/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

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DRAWING TITLE

850B HULL

DATE	8/16/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-01 | SHEET 1 OF 6

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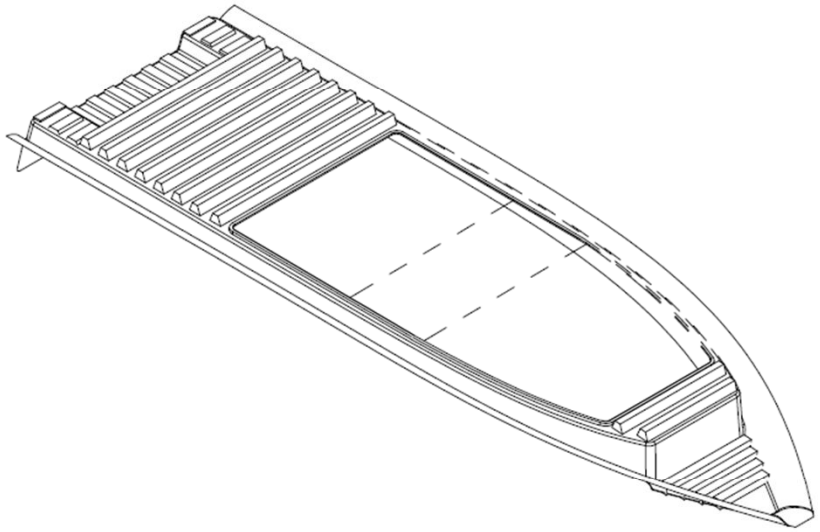
850B- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5	A/R	E LTM 1808 0/90 fabric			
6	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
7	A/R	E-BXM 2408 +/-45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-LM 1810 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
9	80 LF	TR4030	Compsys	TR4030	
10	10 LF	RT3030X	Compsys	RT3030X	
11	15 LF	TR4010	Compsys	TR4010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	INITIAL ISSUES	03/01/11	
	B	HATCH REVISION	08/18/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE: 850B DECK

DATE	6/24/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-2 | SHEET 1 OF 3

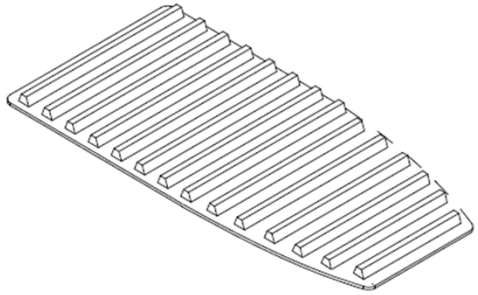
STRUCTURAL COMPOSITES ® LOCKHEED MARTIN ATI ®ZODIAC®

850B- Hatch Drawings

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
14	60 LF	TR4030	Compsys	TR4030	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850B HATCH

DATE	6/24/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-3 | SHEET 1 OF 3

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850B – Laminate Schedule

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 2 x 3610 (Bottom) 2x 1708 (Sides)
- Stringers – TR4030X /1810 / 1208
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 2 x 2408
- Deck Framing – TR4030 (24oz 0/90)
- Transom – Gel Coat / 2oz CSM / 1 x 3610 / Transom Preforms (24oz +/-45, bottom overlays (2 x1810), 1x 3610

850B - FEA

- FEA Model of 850B Hull/Deck
- Applied Load to Hull Panels
- Deflection and Stress Reactions
- 11 Load Cases Total
  - Small Area Slamming (SAS)
    - Five Load Cases
      - 2 Aft and Fwd panels between bulkheads (Inboard and Outboard)
      - Included Stringer

850B- FEA

- Large Area Slam (LAS)
- Calm Water Planning (CWP)
- Boat Lift Points (BLP)
- Gun Mount
  - Longitudinal (GML)
  - Transverse (GMT)
- Transom Load Analysis (TLA)

850B- FEA Load Cases

Load Case	Load ID	Description	Pressure	Load
1	AMI	Aft Mid Inboard, SAS	10psi	--
2	AMO	Aft Mid Outboard, SAS	10psi	--
3	FI	Fwd Inboard, SAS	10psi	--
4	F0	Fwd Outboard, SAS	10psi	--
5	STR	Stringer, SAS	10psi	--
6	LAS	Large Area Slam	5.57 psi	52,400lbs
7	CWP	Calm Water Planning	1.23 psi	13,100lbs
8	BLP	Boat Lift Points	--	33,600lbs
9 10	GML GMT	Gun Mount-Longitudinal Transverse	--	1500lbs 1500lbs
11	TLA	Transom Load Analysis (Thrust/Weight)	--	6600lbs 3072lbs

850B- FEA Analysis











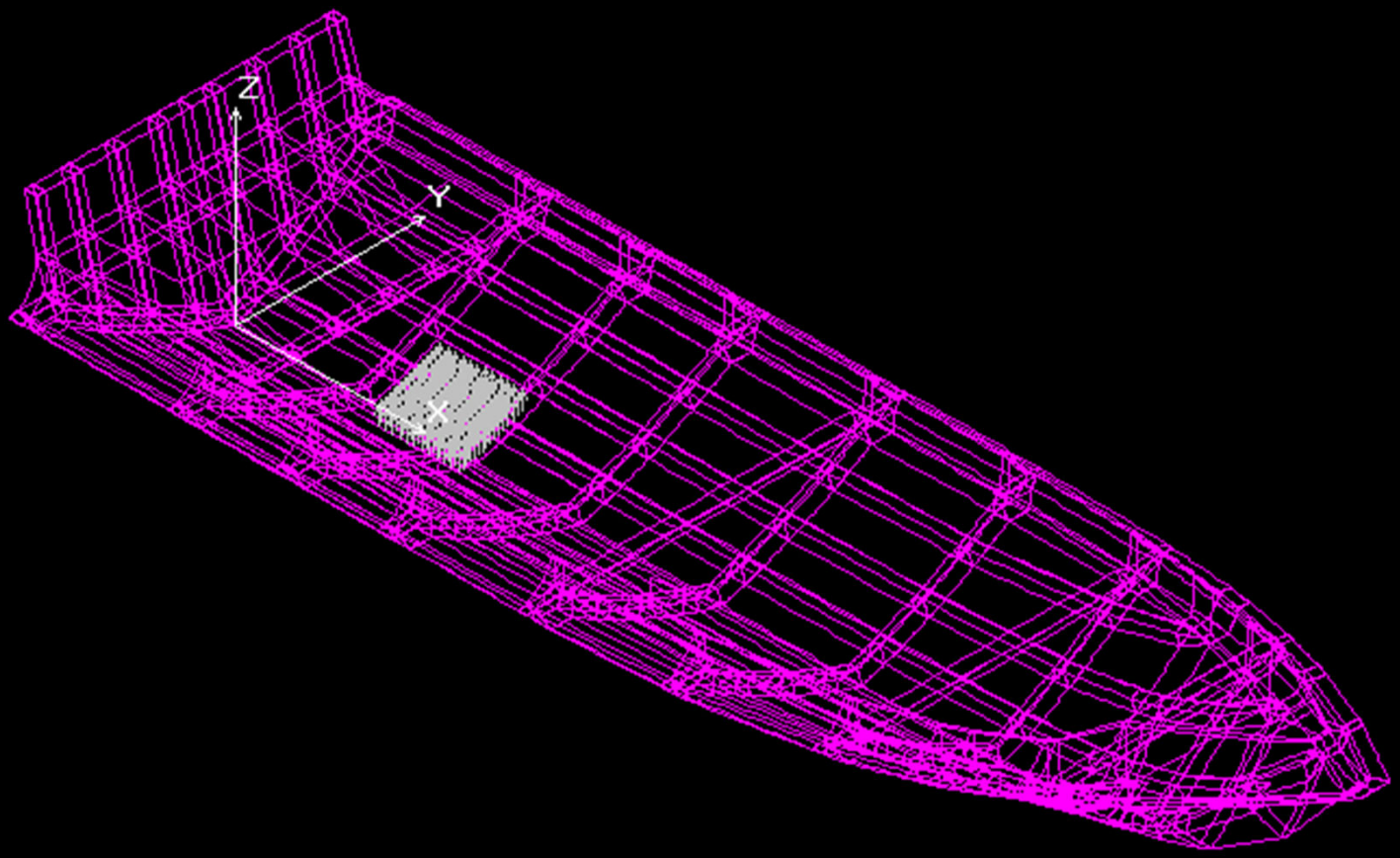
850B- FEA Analysis: Small Area Slamming (SAS)



Small Area Pressure Load

- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

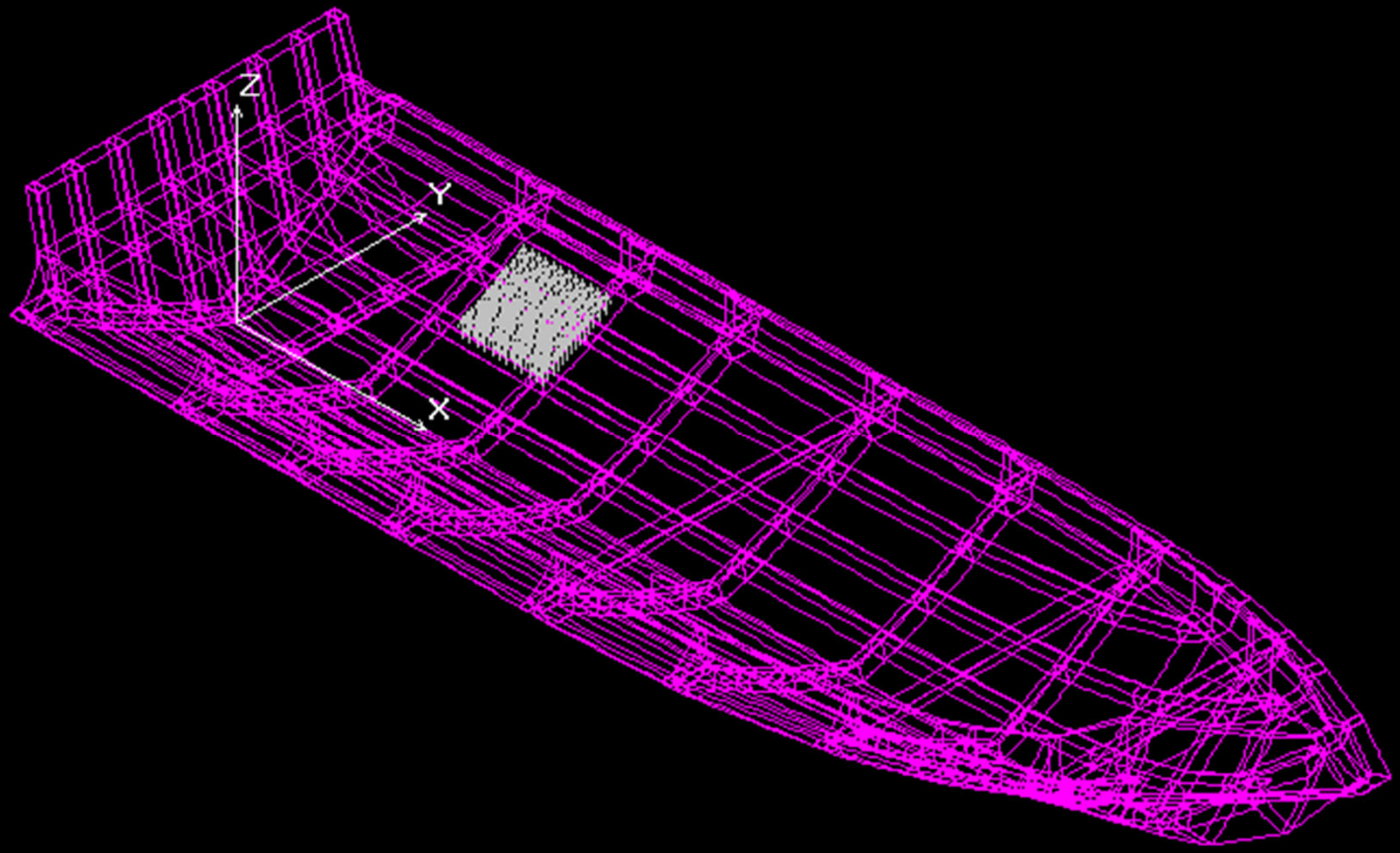
LC1- AMI-10 psi Pressure Load



LC1- AMI- Summary

- Hull range of deflection 0.2 to -0.52 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0028 in/in
- Maximum framing stress 12,000 psi
- Maximum hull shell stress 7,000 psi

LC2- AMO-10 psi Pressure Load

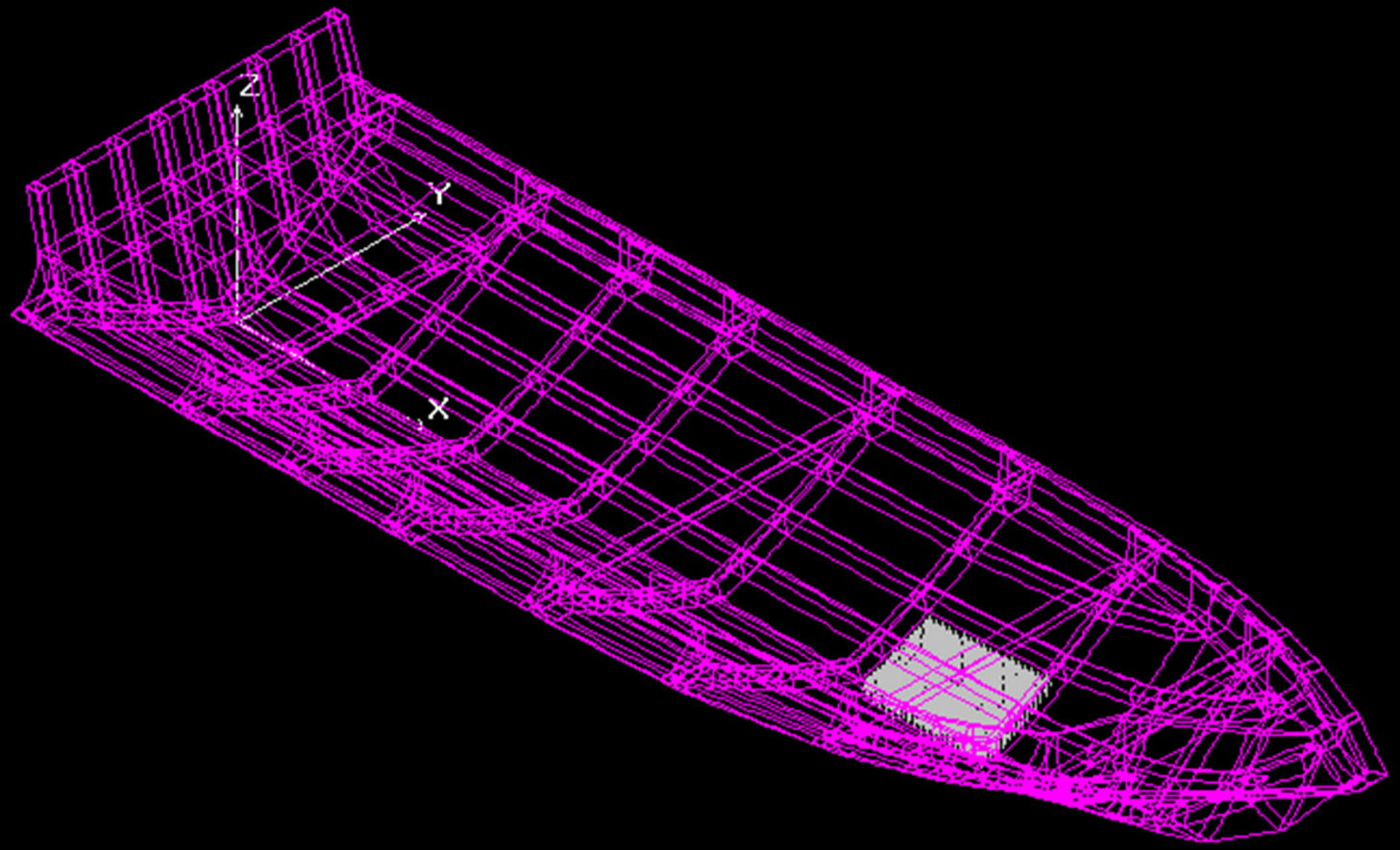


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LC2- AMO- Summary

- Hull range of deflection 0.48 to -0.51 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0030 in/in
- Maximum framing stress 15,000 psi
- Maximum hull shell stress 7,000 psi

LC3- FI-10 psi Pressure Load

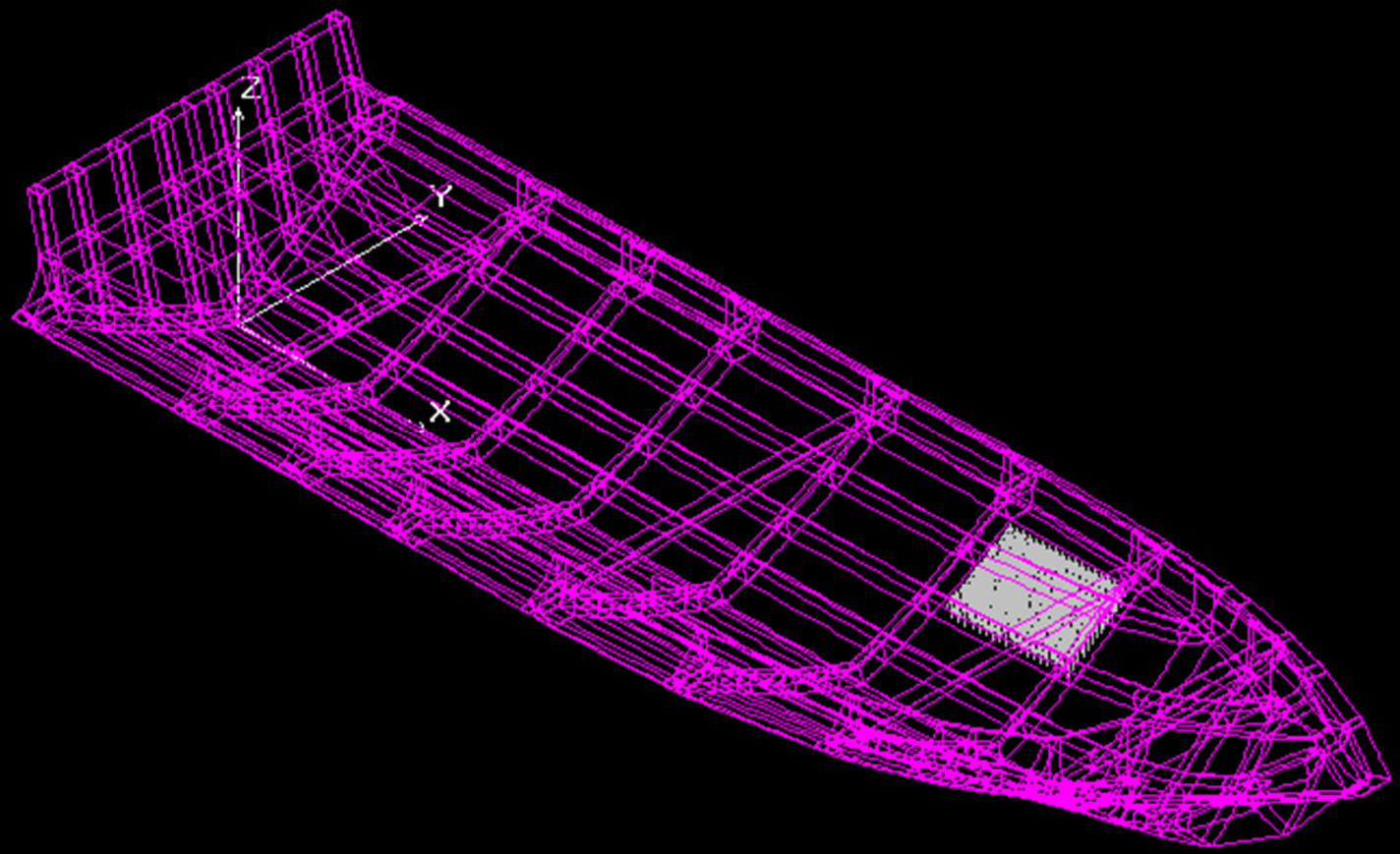


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LC3- FI- Summary

- Hull range of deflection 0.41 to -0.57 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.0030 in/in
- Maximum framing stress 13,000 psi
- Maximum hull shell stress 8,000 psi

LC4- FO-10 psi Pressure Load

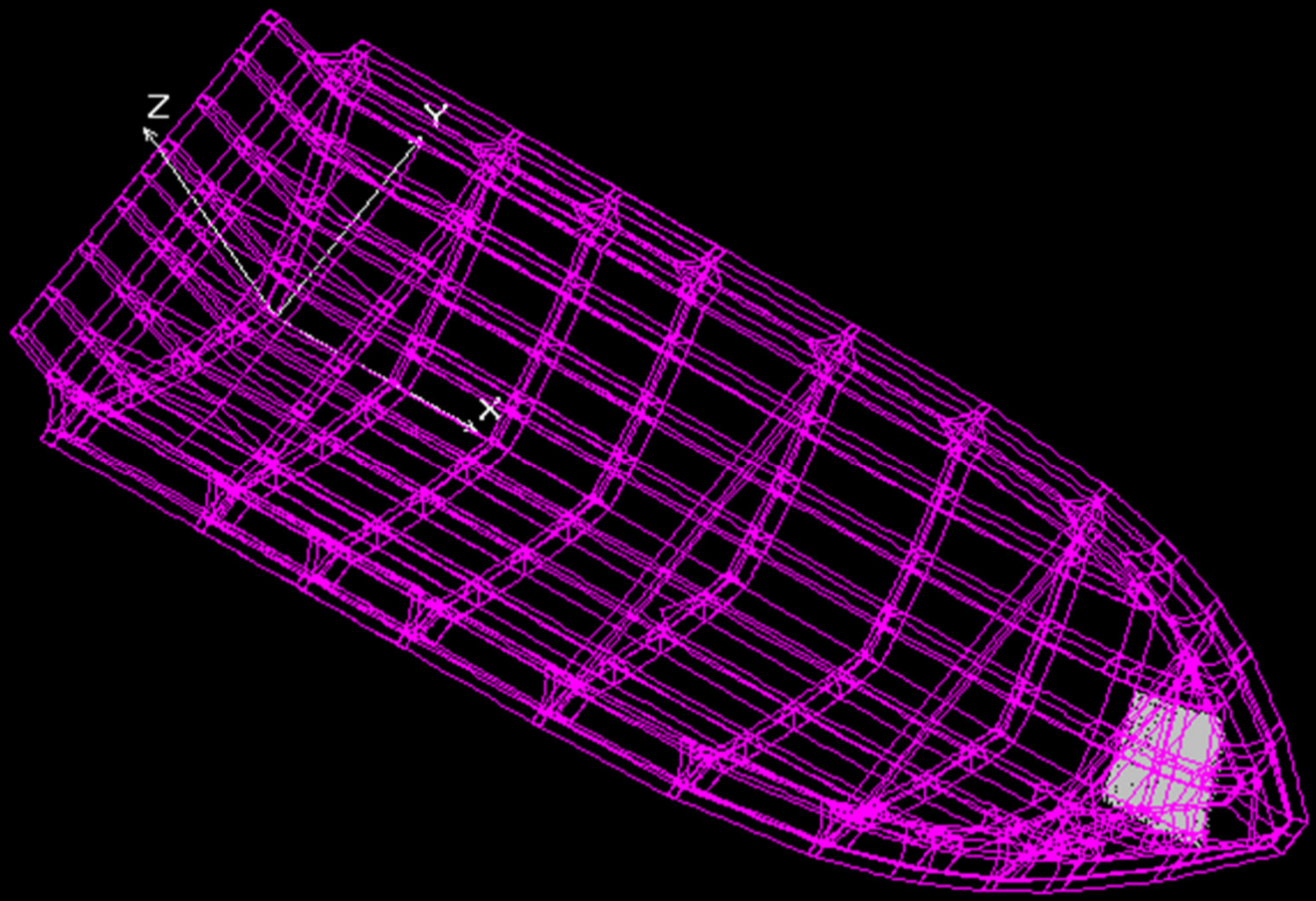


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LC4- FO- Summary

- Hull range of deflection 0.73 to -0.58 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.0035 in/in
- Maximum framing stress 16,000 psi
- Maximum hull shell stress 7,000 psi

LC5- STR-10 psi Pressure Load



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LC5- STR- Summary

- Hull range of deflection 0.43 to -0.69 in.
- Local panel deflection 0.22 in.
- Maximum strain 0.0030 in/in
- Maximum framing stress 12,000 psi
- Maximum hull shell stress 7,000 psi

LC(1-5)- SAS Summary

Range of maximum values in SAS cases

- Hull range of deflection 1.07 to -0.69 in.
- Local panel deflection 0.16 to 0.25 in.
- Maximum strain 0.0028 to 0.0035 in/in
- Max framing stress 12,000 to 19,000 psi
- Max hull shell stress 7,000 to 9,000 psi

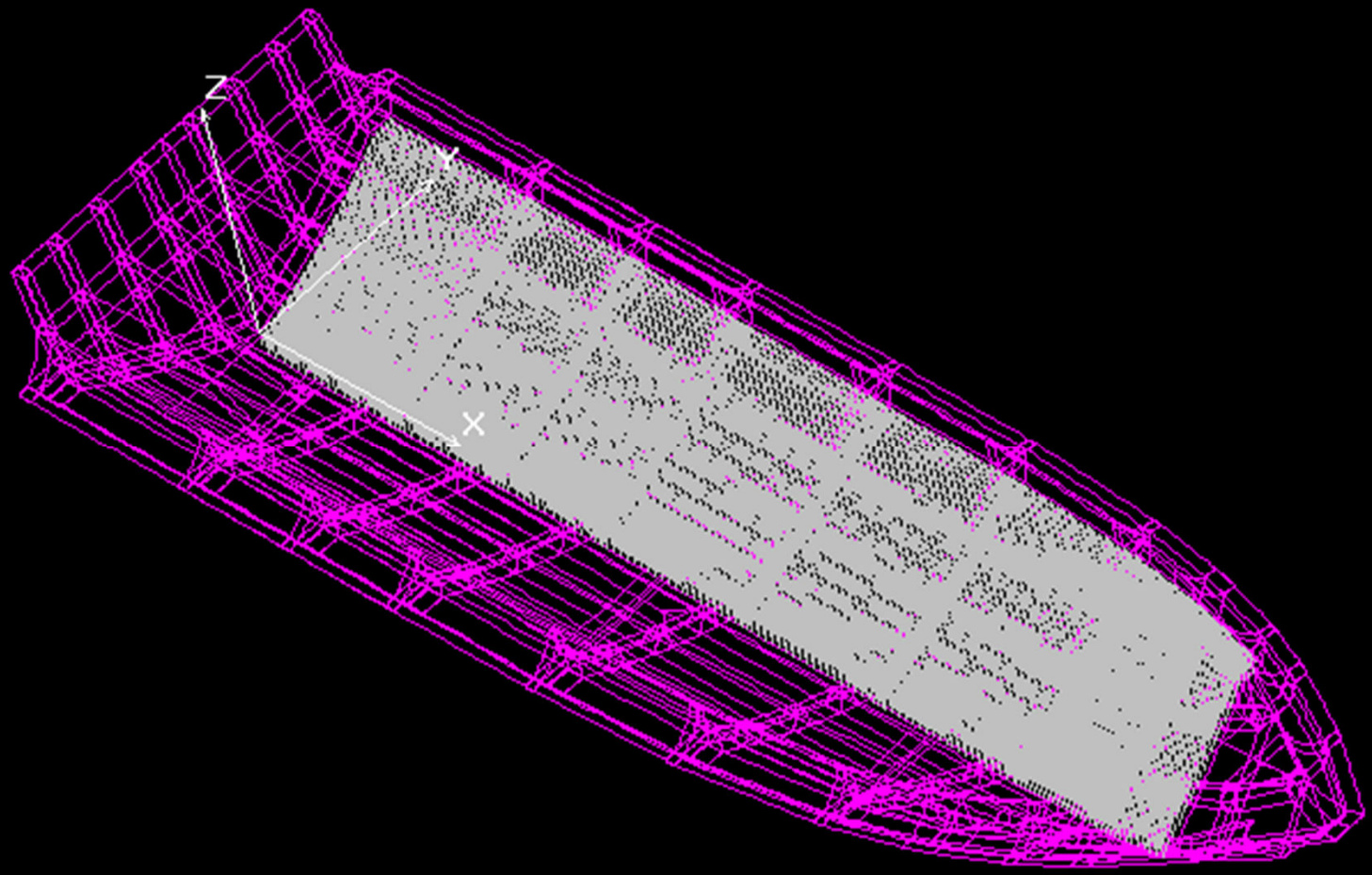
850B- FEA Analysis: Large Area Slam (LAS)



LC6-LAS- Loading

- Pressure load 5.57 psi
- Total load 52,400 lbs
- 13,100 lbs running weight at 4 g's

LC6-LAS- 5.57 psi Pressure Load



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850B- LAS Summary

- Hull range of deflection 3.84 to -1.77 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.008 in/in
- Maximum framing stress 45,000 psi
- Maximum hull shell stress 15,000 psi

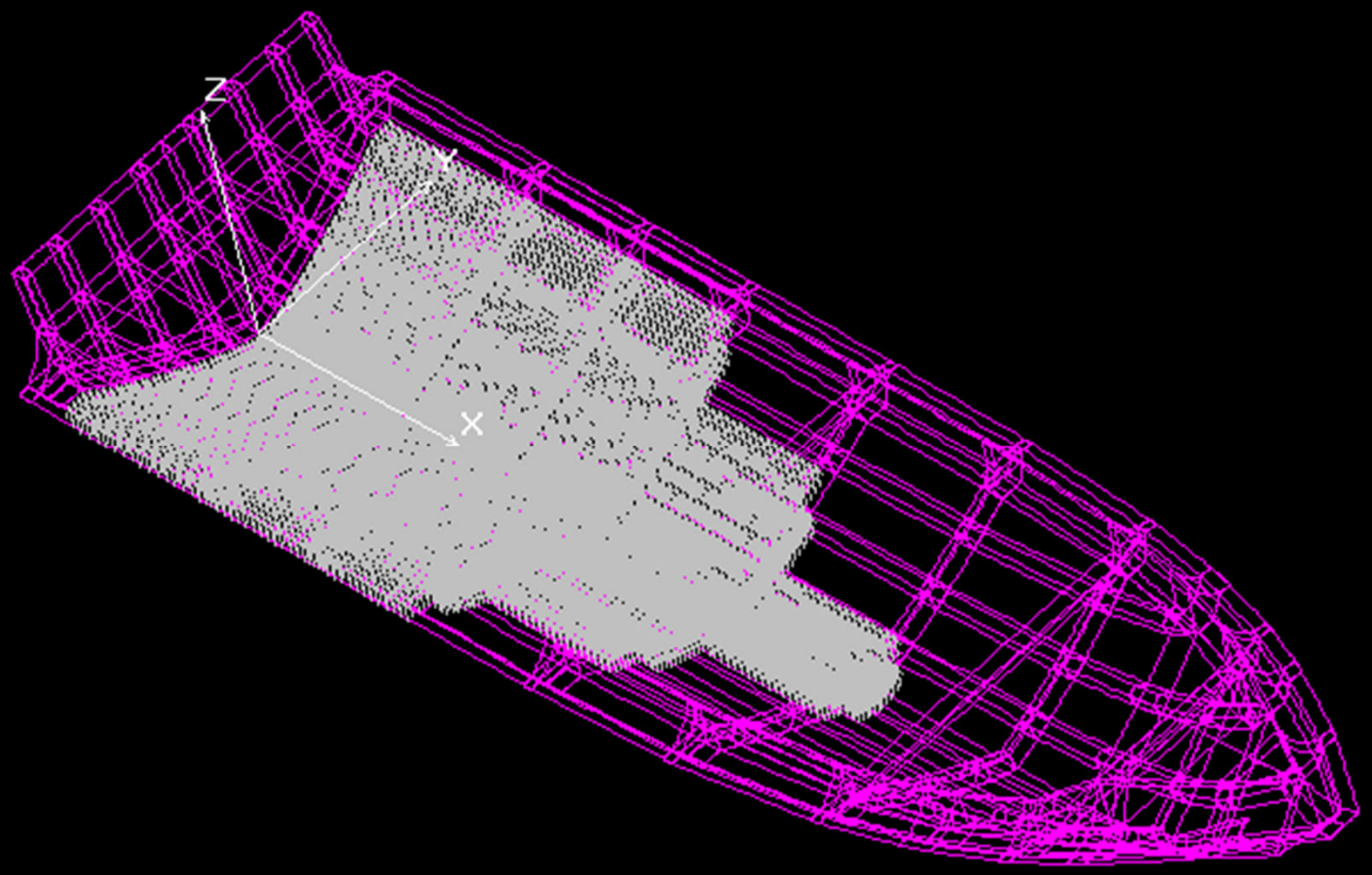
850B- FEA Analysis: Calm Water Planning (C.W.P.)



LC7-CWP- Load

- Boat weight 13,100 lbs
- Bottom pressure 1.23 psi (13,100 lbs total)

LC7-CWP- 1.1psi Pressure Load



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850B- CWP Summary

- Range of deflection 0.78 in.
- Local panel deflection 0.03 in
- Maximum strain 0.001 in/in
- Maximum longitudinal cap stress 2800 psi
- Maximum transverse cap stress 4000 psi
- Maximum transverse stress 1400 psi

850B- FEA Analysis: Boat Lifting Points (B.L.P.)

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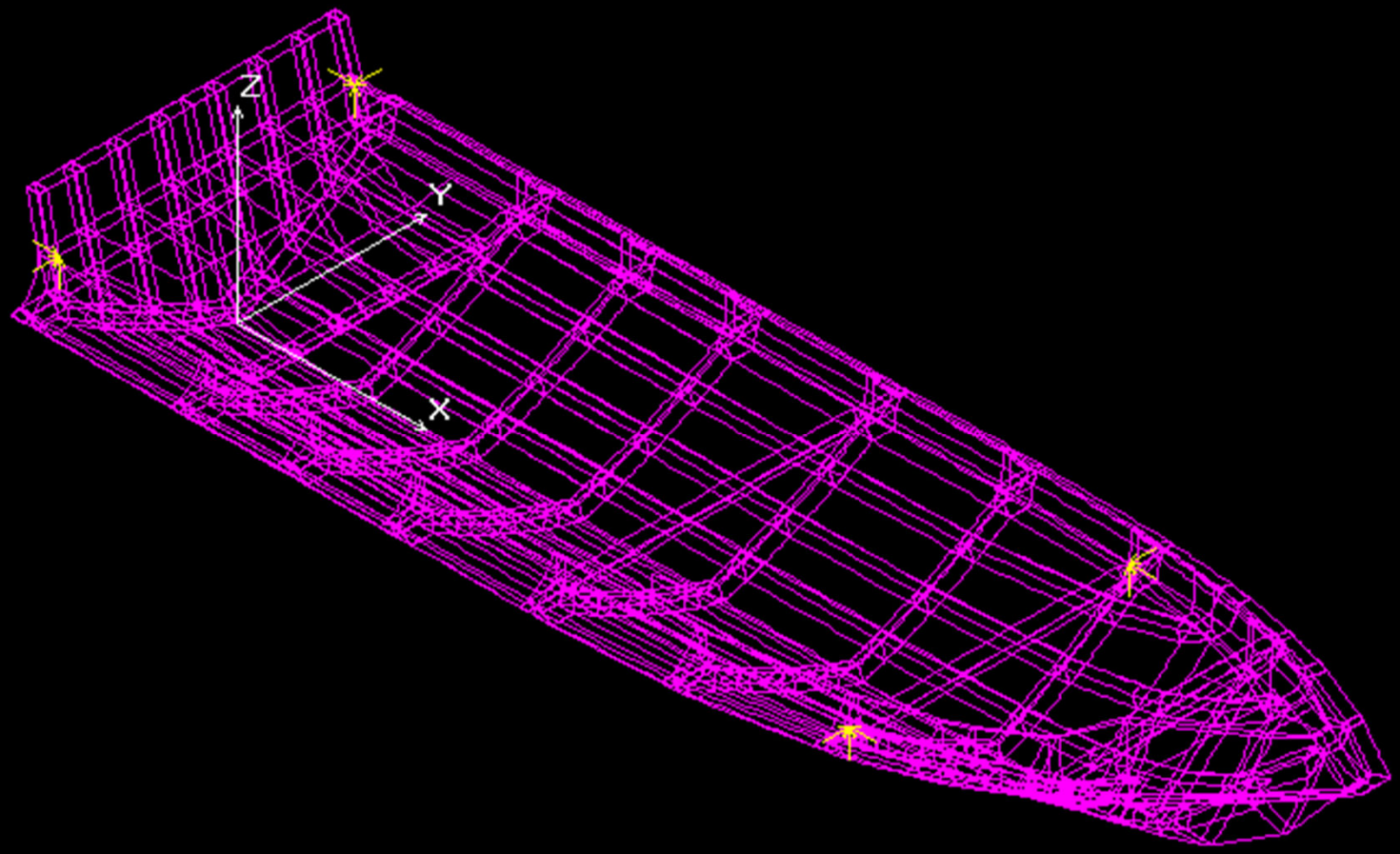
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
  - Redesigned to accommodate tube mounting.
  - Positioned for design LCG

LC8- BLP- Load Data

- Lift weight 5600, SF 6 (33,600)
- 4 point lift
- F_z all four lift points +8,400 lbs
- F_x at aft two lift points +13,527 lbs
- F_x at fwd two lift points -13,527 lbs
- F_y at stbd two lift points +5,381 lbs
- F_y at port two lift points -5,381 lbs

LC8- BLP- Force Vector at Lift Points



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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints $F_r < 1$ lb
- Thus constraints do not affect results

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LC8- BLP- Lift Analysis Summary

- Hull range of deflection 1.2 to -2 in.
- Maximum strain 0.016 in/in
- Maximum framing stress 60,000 psi
- Maximum hull shell stress 8,500 psi

850B- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

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LOCKHEED MARTIN

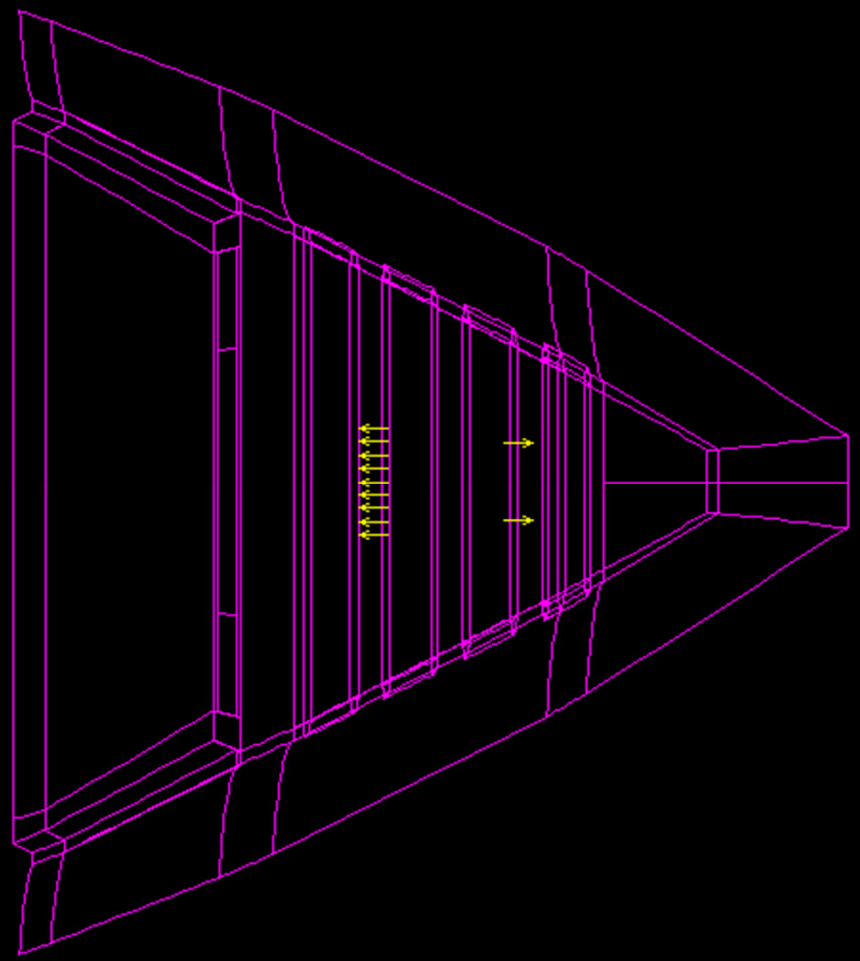
ZODIAC®

Gun Mount Framing Notes

- Four transverse frames, TR3030X, are placed on five inch centers
- Skin laminate is 2oz, 2 x 2408,2 x 3610
- Frame laminate:
  - 24 oz (+/-45) on PRISMA Beam
  - 3 layers 1810 warp uni
  - 2408 (+/-45) cover fabric

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LC9- GML- Long. Loading

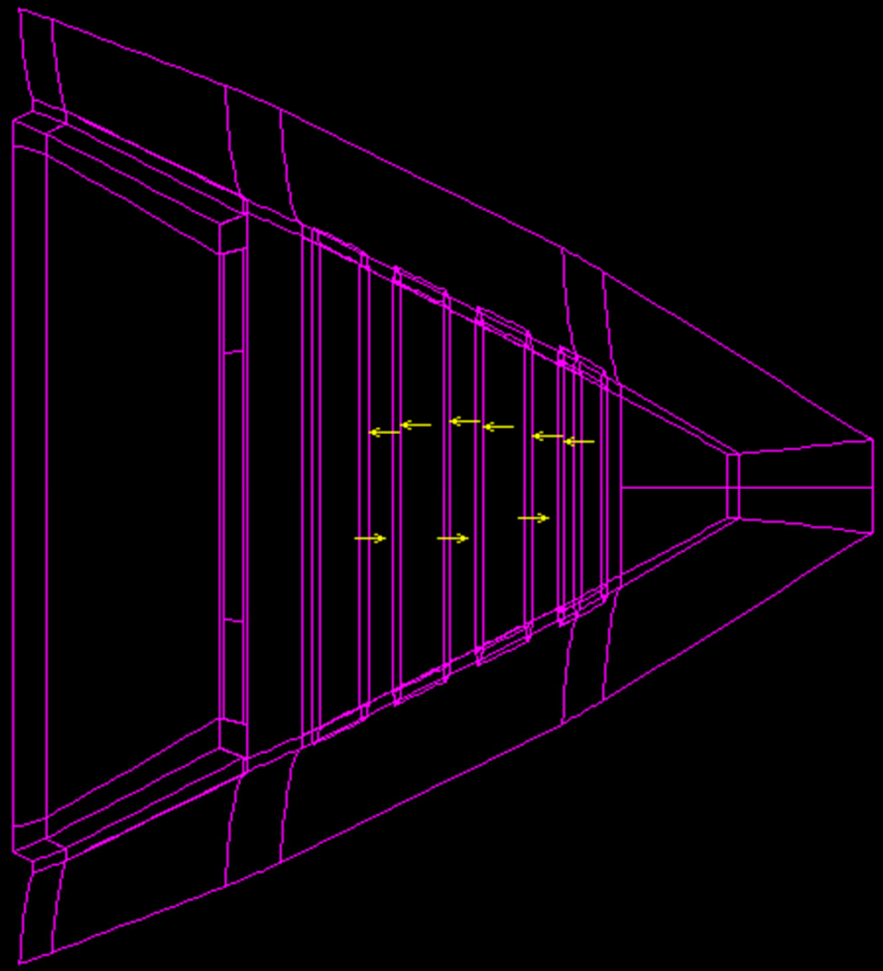


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850B- G.M.L- Summary

- Range of deflection 0.29 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 15,500 psi

LC10- GMT- Trans. Loading



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850A- G.M.T- Summary

- Range of deflection 0.25 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 5,000 psi

Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
  - Slight weight increase from Rev 0
- FOS for strength in excess of 10

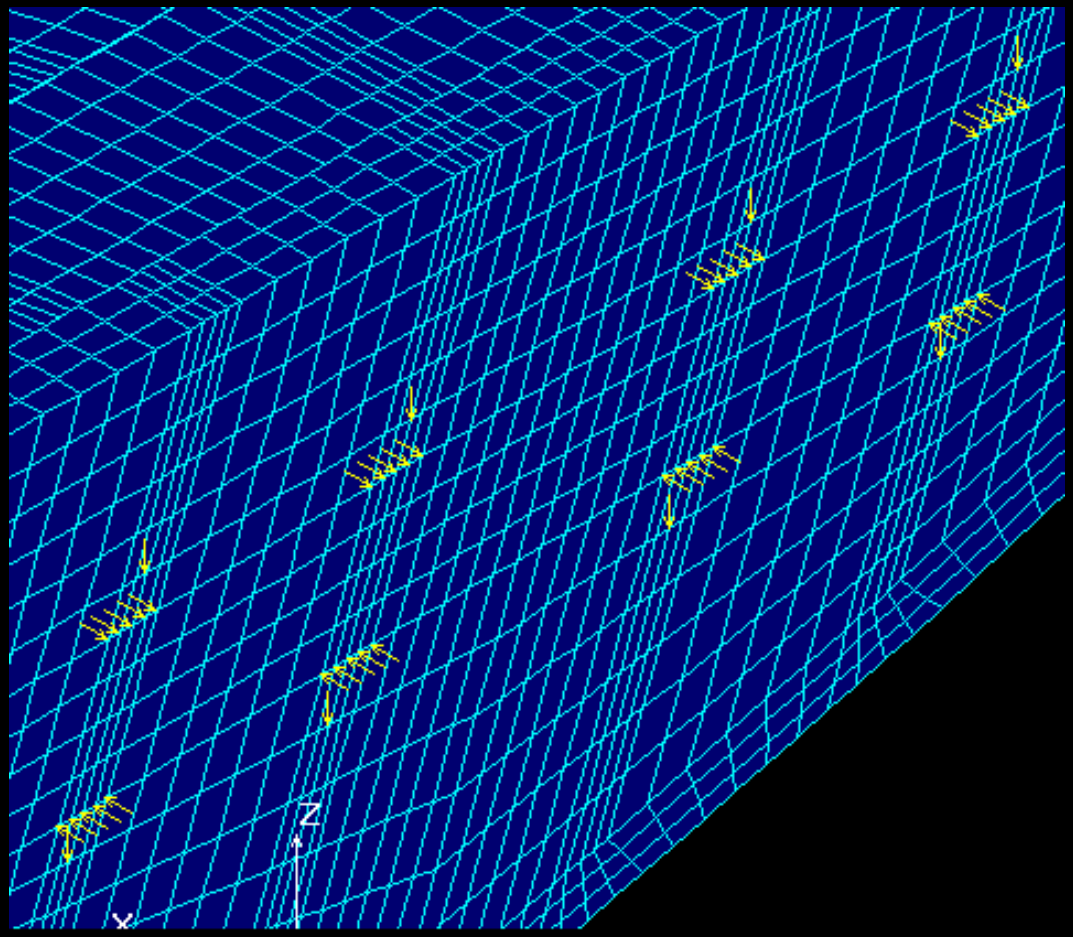
850B- FEA Analysis: Transom Load Analysis (TLA)



Transom Load Analysis-LC11

- Motor weight
  - 512 lbs each
  - Assume 3 g load, thus 1536 lbs each
  - 4 bolts for each motor
  - Applied as Z force of 384 lbf at each of the 8 mounting bolts
- Thrust of 3300 lbf for each motor (estimated)
  - 25 in shaft
  - Fx = -825 lbf on 10 nodes at top of bracket for each motor
  - Fx = 1150 lbf on 10 nodes at bottom of bracket for each motor-45) cover fabric

LC11- Transom Loads



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850B- LC11- TLA Summary

- Transom range of deflection 0.6 to -0.7 in.
- Local panel deflection 0.2 in.
- Maximum strain 0.012 in/in
- Maximum framing stress 50,000 psi
- Maximum Transom shell stress 20,000 psi

Weight Evaluation

Boat Weights (lb)				
Segment	Baseline	850 A	850 B	850 B-OM
Fabrication Method	Open Mold	Open Mold	VARTM	Open Mold
Hull	1200	867	872	960
Deck	665	448	362	398
Console	540	350	350	350
Total	2405	1665	1584	1708
% Current	100%	69%	66%	71%
% Savings	--	31%	34%	29%

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 850A- Exceeds Metrics, On Target
  - 850B- Exceeds Metrics, On Target

850B- Extended Drawings and FEA Analysis Slides



850B- Complete Drawings Package











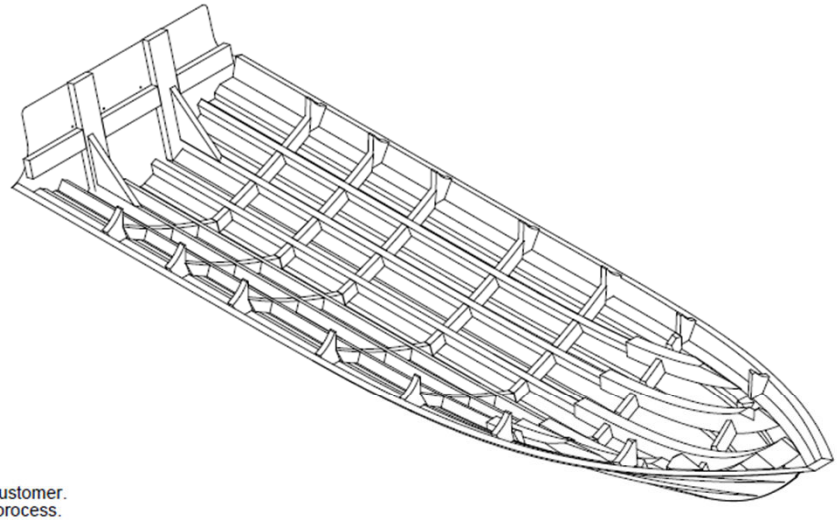
850B- Hull Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/-45 fabric
9	A/R	E-LTBXM 1208 Quad fabric	Vectorply		
10	A/R	E-LM 1810 fabric 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
11		not used			
12		not used			
13		not used			
14	140 LF	TR4030X	Compsys	TR4030X	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850IMB-SFOS	
16	1	Starboard Mid Stringer	Compsys	BCG850IMB-SFMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850IMB-SFIS	
18	1	Port Outboard Stringer	Compsys	BCG850IMB-PFOS	
19	1	Port Mid Stringer	Compsys	BCG850IMB-PFMS	
20	1	Port Inboard Stringer	Compsys	BCG850IMB-PFIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	6 LF	TR6026 with 36oz double Bias	Compsys	TR6026	
26	7 LF	TR8026 with 36oz double Bias	Compsys	TR8026	
27	8	Bulkhead Wings - Bkhds C-G (P&S)	Compsys	BCG850IMB-P/SDS1-5	
28	1	Bulkhead Wing - Bkhds B (P)	Compsys	BCG850IMB-DS8	
29	1	Bulkhead Wing - Bkhds B (S)	Compsys	BCG850IMB-DS8	
30	1	Bulkhead Wing - Bkhds A (P)	Compsys	BCG850IMB-DS7	
31	1	Bulkhead Wing - Bkhds A (S)	Compsys	BCG850IMB-DS7	
32	1	FS2010	Compsys	FS2010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	Initial issues	03/01/11	
	B	TRANSOM KNEES	08/18/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850B HULL

DATE	8/16/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-01 | SHEET 1 OF 6

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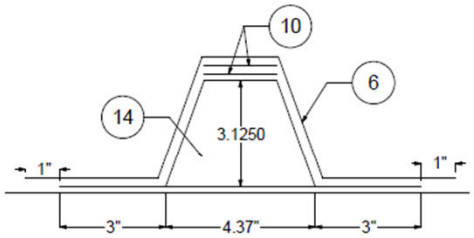
850B- Hull Drawings- BOM

BOM

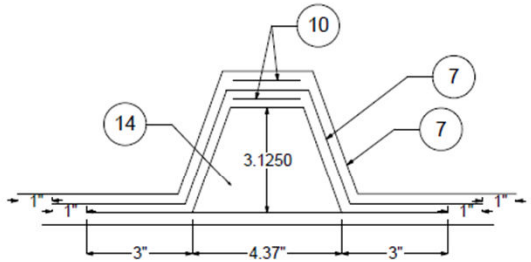
ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5		not used			
6	A/R	E-BXM 1208 +/- 45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 3608 +/- 45 fabric	Vectorply	E-BXM 3608	+/-45 fabric
9	A/R	E-LTBXM 1208 Quad fabric	Vectorply		
10	A/R	E-LM 1810 fabric 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
11		not used			
12		not used			
13		not used			
14	140 LF	TR4030X	Compsys	TR4030X	24oz double bias
15	1	Starboard Outboard Stringer	Compsys	BCG850IMB-SFOS	
16	1	Starboard Mid Stringer	Compsys	BCG850IMB-SFMS	
17	1	Starboard Inboard Stringer	Compsys	BCG850IMB-SFIS	
18	1	Port Outboard Stringer	Compsys	BCG850IMB-PFOS	
19	1	Port Mid Stringer	Compsys	BCG850IMB-PFMS	
20	1	Port Inboard Stringer	Compsys	BCG850IMB-PFIS	
21		not used			
22		not used			
23		not used			
24		not used			
25	6 LF	TR6026 with 36oz double Bias	Compsys	TR6026	
26	7 LF	TR8026 with 36oz double Bias	Compsys	TR8026	
27	8	Bulkhead Wings - Bkhds C-G (P&S)	Compsys	BCG850IMB-P/SDS1-5	
28	1	Bulkhead Wing - Bkhds B (P)	Compsys	BCG850IMB-DS6	
29	1	Bulkhead Wing - Bkhds B (S)	Compsys	BCG850IMB-DS6	
30	1	Bulkhead Wing - Bkhds A (P)	Compsys	BCG850IMB-DS7	
31	1	Bulkhead Wing - Bkhds A (S)	Compsys	BCG850IMB-DS7	
32	1	FS2010	Compsys	FS2010	

850B- Hull Drawings

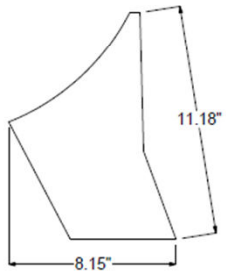
LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
14	TR4030X	
10	E-LM 1810 0 fabric - 3" wide	
6	E-BXM 1208 +/- 45 fabric	
7	E-BXM 2408 +/- 45 fabric	



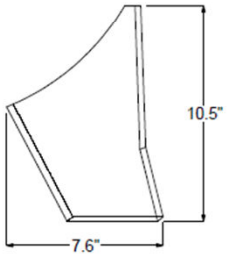
LONGITUDINAL TR4030X
TYPICAL FRAMING DETAIL



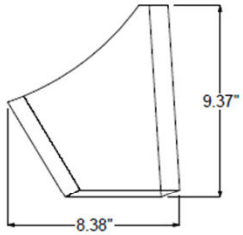
TRANSVERSE TR4030X
TYPICAL FRAMING DETAIL



DETAIL E-34
BULKHEAD WING C-G (P&S)



DETAIL E-36
BULKHEAD WING B (P&S)



DETAIL D-38
BULKHEAD WING A (P&S)

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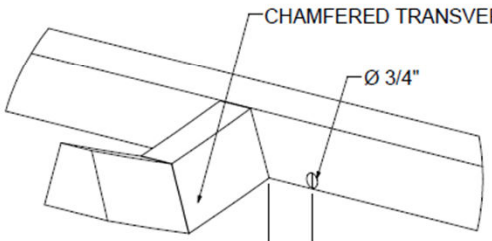
850B-HULL

DATE	8/16/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

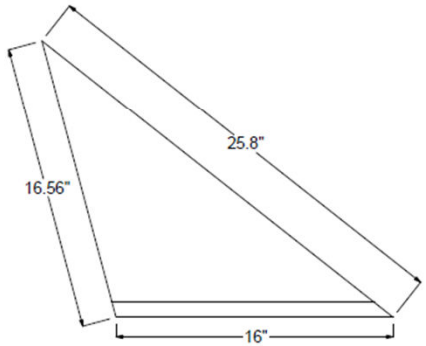
SCALE: NTS | JOB No. | DWG No. 9020-850B-01 | SHEET 5 OF 6

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850B- Hull Drawings



DETAIL C-42
LIMBER HOLE
(applies to all longitudinals)



DETAIL C-46
TRANSOM KNEE (P&S)

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850B-HULL

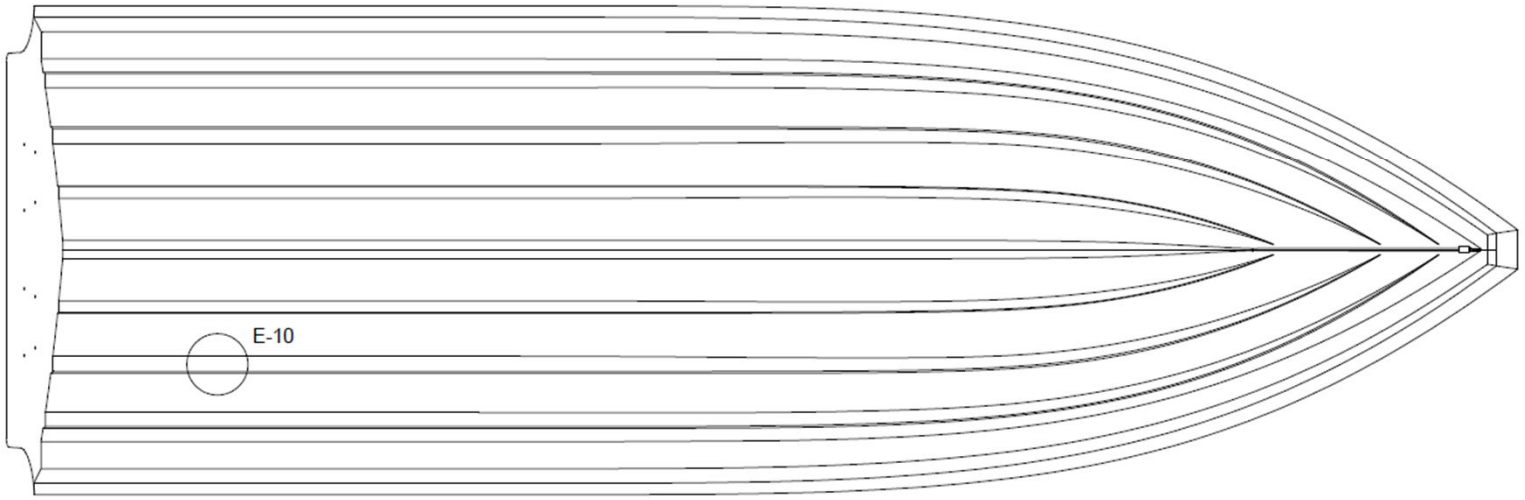
DATE	8/16/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-01 | SHEET 6 OF 6

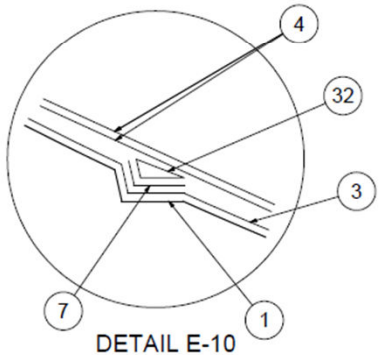
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850B- Hull Drawings

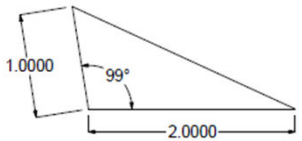
LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
3	2oz Chopped Strand Mat	
7	E-BXM 2408 +/- 45 fabric (in strakes only)	see detail
32	FS2010	
4	E LTM 3610 0/90 fabric	
4	E LTM 3610 0/90 fabric	



HULL- PLAN VIEW



DETAIL E-10



FS2010
STRAKE FILLER

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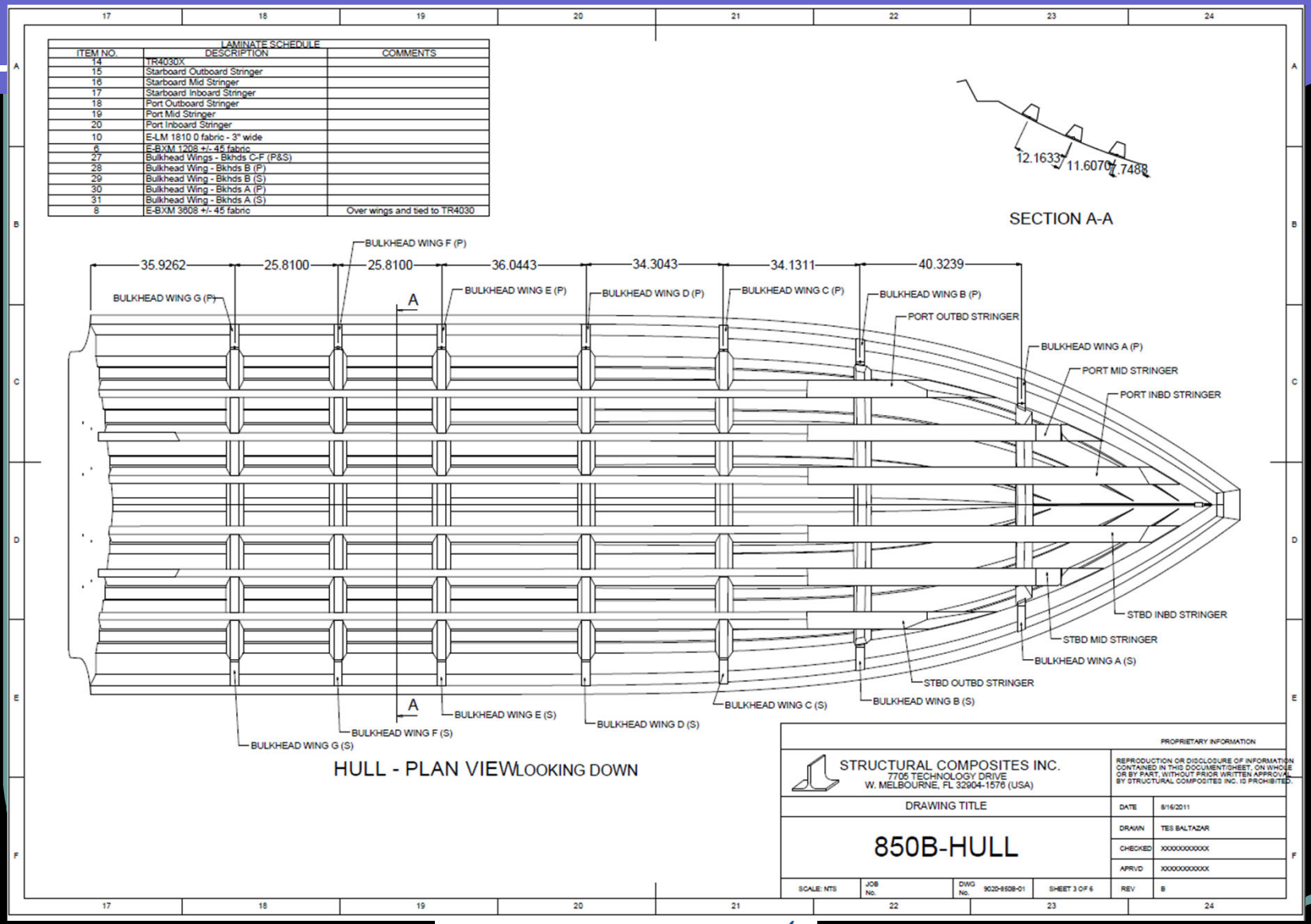
DRAWING TITLE: 850B-HULL

DATE	8/16/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-01 | SHEET 2 OF 6

STRUCTURAL COMPOSITES ® LOCKHEED MARTIN ATI ®ZODIAC®

850B- Hull Drawings



LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
14	TR4030X	
15	Starboard Outboard Stringer	
16	Starboard Mid Stringer	
17	Starboard Inboard Stringer	
18	Port Outboard Stringer	
19	Port Mid Stringer	
20	Port Inboard Stringer	
10	E-LM 1810 0 fabric - 3" wide	
6	E-BXM 1208 +/- 45 fabric	
27	Bulkhead Wings - Bkhds C-F (P&S)	
28	Bulkhead Wing - Bkhds B (P)	
29	Bulkhead Wing - Bkhds B (S)	
30	Bulkhead Wing - Bkhds A (P)	
31	Bulkhead Wing - Bkhds A (S)	
8	E-BXM 3608 +/- 45 fabric	Over wings and tied to TR4030

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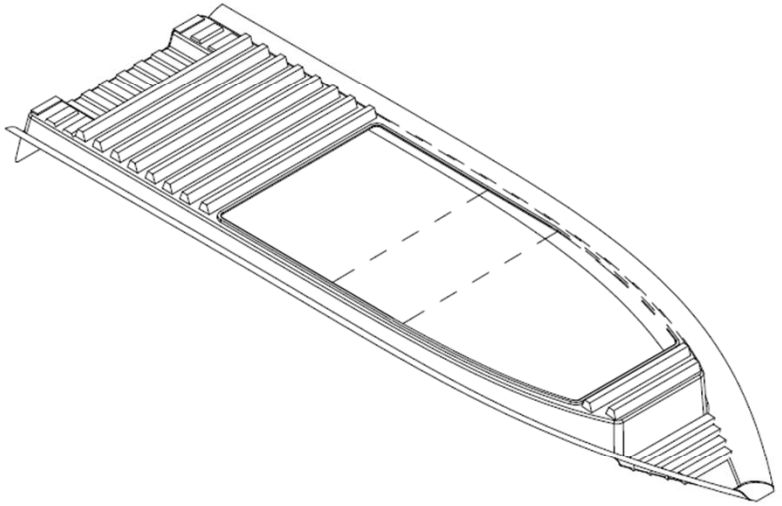
850B- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
5	A/R	E LTM 1808 0/90 fabric			
6	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
7	A/R	E-BXM 2408 +/- 45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-LM 1810 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
9	60 LF	TR4030	Compsys	TR4030	
10	10 LF	RT3030X	Compsys	RT3030X	
11	15 LF	TR4010	Compsys	TR4010	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	INITIAL ISSUES	03/01/11	
	B	HATCH REVISION	08/18/11	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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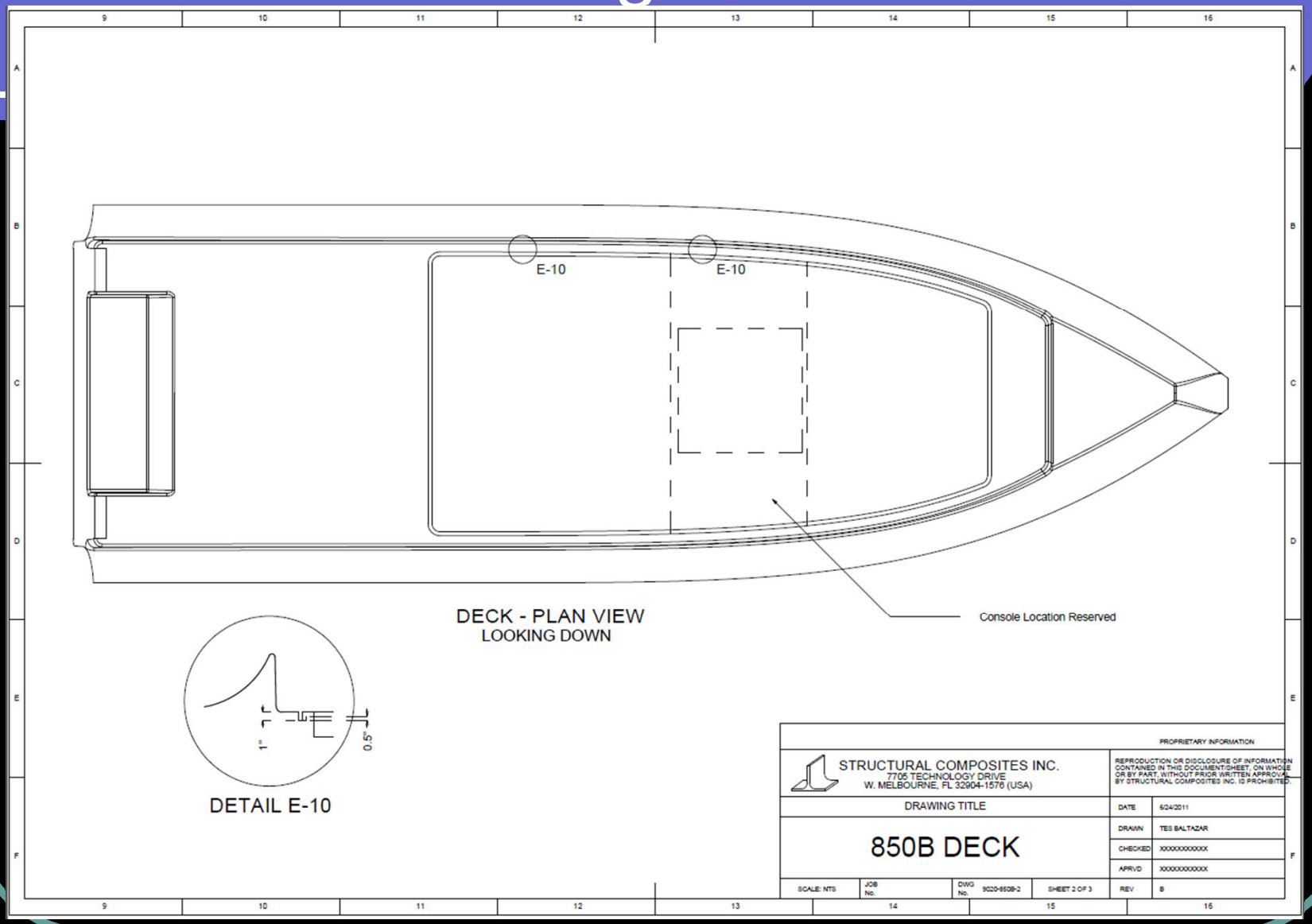
DRAWING TITLE: 850B DECK

DATE	6/24/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-2 | SHEET 1 OF 3

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850B- Deck Drawings



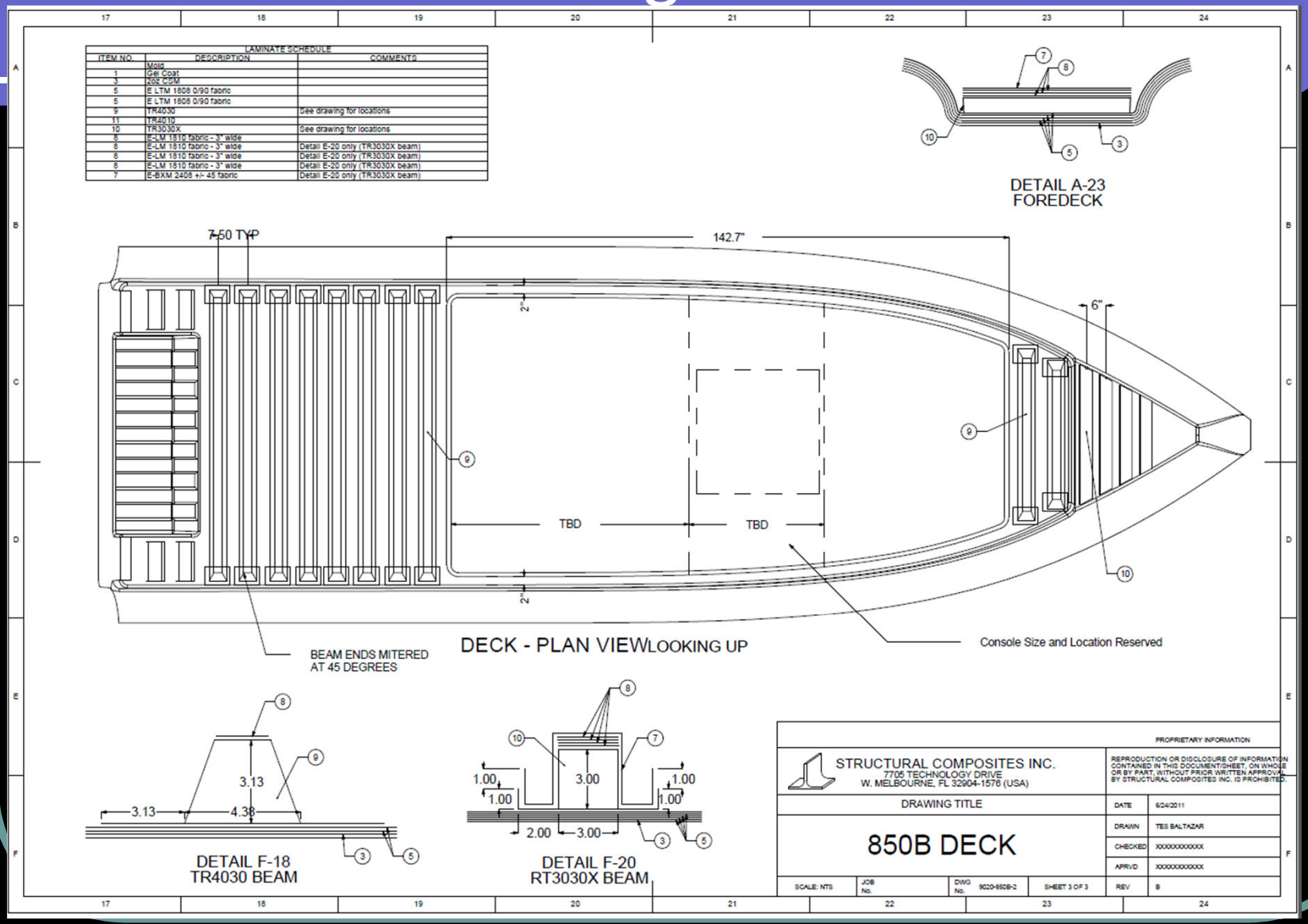
STRUCTURAL COMPOSITES®

LOCKHEED MARTIN

ATI

ZODIAC®

850B- Deck Drawings



LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
1	Mold	
3	Gel Coat	
5	2oz CSM	
5	E LTM 1808 0/90 fabric	
5	E LTM 1808 0/90 fabric	
9	TR4030	See drawing for locations
11	TR4010	
10	TR3030X	See drawing for locations
8	E-LM 1810 fabric - 3" wide	
8	E-LM 1810 fabric - 3" wide	Detail E-20 only (TR3030X beam)
8	E-LM 1810 fabric - 3" wide	Detail E-20 only (TR3030X beam)
8	E-LM 1810 fabric - 3" wide	Detail E-20 only (TR3030X beam)
7	E-BXM 2408 +/- 45 fabric	Detail E-20 only (TR3030X beam)

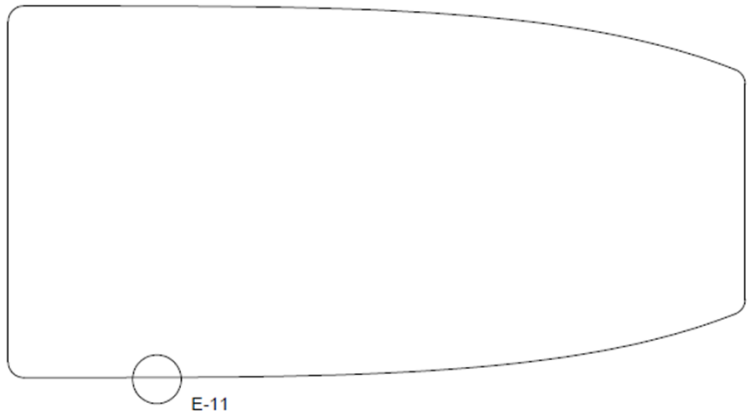
STRUCTURAL COMPOSITES ®

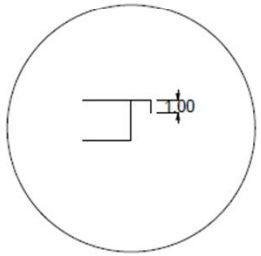
LOCKHEED MARTIN

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ZODIAC®

850B- Hatch Drawings





DETAIL E-11

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DRAWING TITLE

850B HATCH

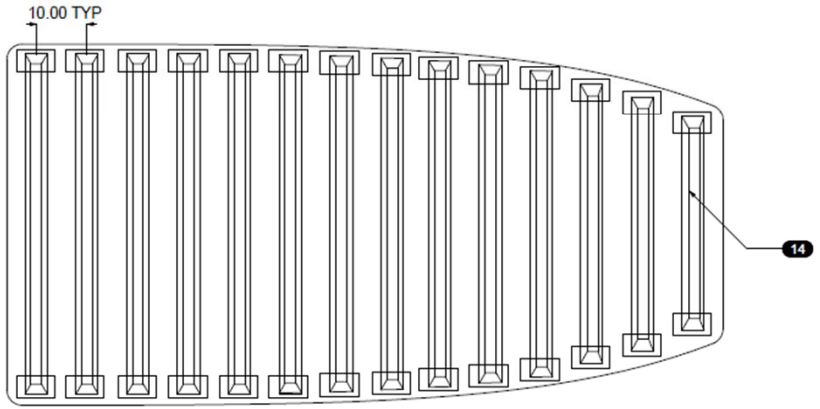
DATE	6/24/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

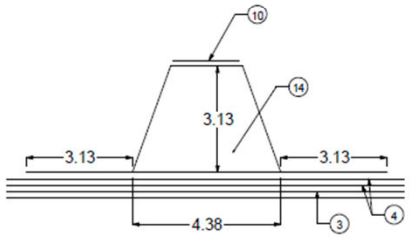
SCALE: NTS | JOB No. | DWG No. 9020-850B-3 | SHEET 2 OF 3

STRUCTURAL COMPOSITES ®
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BRUNSWICK COMMERCIAL & GOVERNMENT PRODUCTS

850B- Hatch Drawings

ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
3	2oz CSM	
4	E LTM 3610 0/90 fabric	
14	TR4030	
10	E-LM 1810 0 fabric - 3" wide	





DETAIL E-18
TR4030 BEAM

PROPRIETARY INFORMATION

STRUCTURAL COMPOSITES INC.
7705 TECHNOLOGY DRIVE
W. MELBOURNE, FL 32904-1576 (USA)

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DRAWING TITLE		
850B HATCH	DATE	6/24/2011
	DRAWN	TES BALTAZAR
	CHECKED	XXXXXXXXXX
	APRVD	XXXXXXXXXX

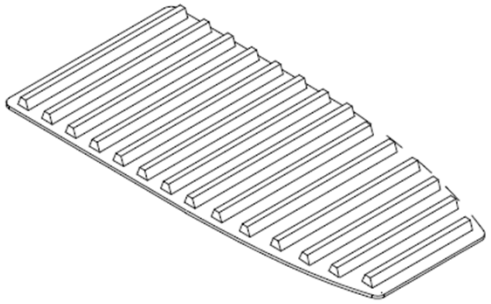
SCALE: NTS	JOB No.	DWG No. 9020-850B-3	SHEET 3 OF 3	REV	B

850B- Hatch Drawings

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	AOC KO22-EBB-00 Resin	Alpha Owens Corning	KO22-EBB-00	
3	A/R	2oz Chopped Strand Mat			
4	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
10	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
14	60 LF	TR4030	Compsys	TR4030	



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

PROPRIETARY INFORMATION

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850B HATCH

DATE	6/24/2011
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	B

SCALE: NTS | JOB No. | DWG No. 9020-850B-3 | SHEET 1 OF 3

STRUCTURAL COMPOSITES ® LOCKHEED MARTIN ATI ZODIAC ®

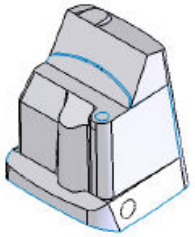
850B- Hardware- Console

BOM

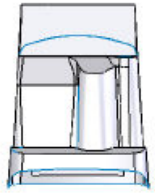
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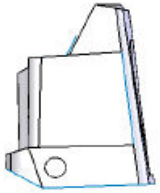
REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED









GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

850A CONSOLE

DATE	3/25/2011
DRAWN	TED BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. 8523-8524-1 | SHEET 1 OF 1

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850B – Laminate Schedule

- Hull – Gel Coat / 2oz CSM / 2408 (in strakes only) / FS2010 / 2 x 3610 (Bottom) 2x 1708 (Sides)
- Stringers – TR4030X /1810 / 1208
- Bulkheads/Bulkhead Wings – TR4030X / 2 x 1810 (3in wide) / 1208
- Deck – Gel Coat / 2oz CSM / 2 x 2408
- Deck Framing – TR4030 (24oz 0/90)
- Transom – Gel Coat / 2oz CSM / 1 x 3610 / Transom Preforms (24oz +/-45, bottom overlays (2 x1810), 1x 3610

850B- Complete FEA Analysis



850B- FEA Analysis: Small Area Slamming (SAS)

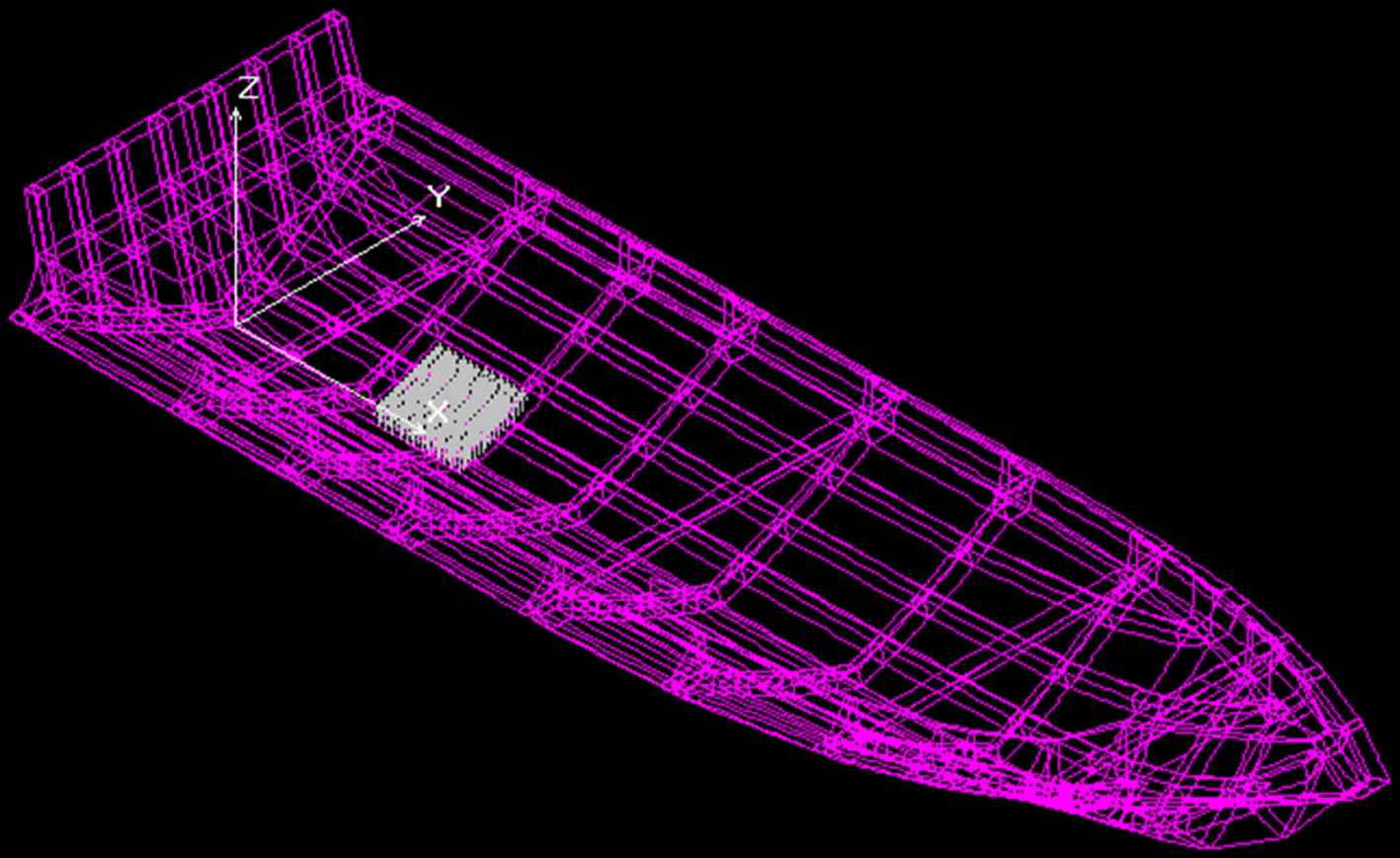


Small Area Pressure Load

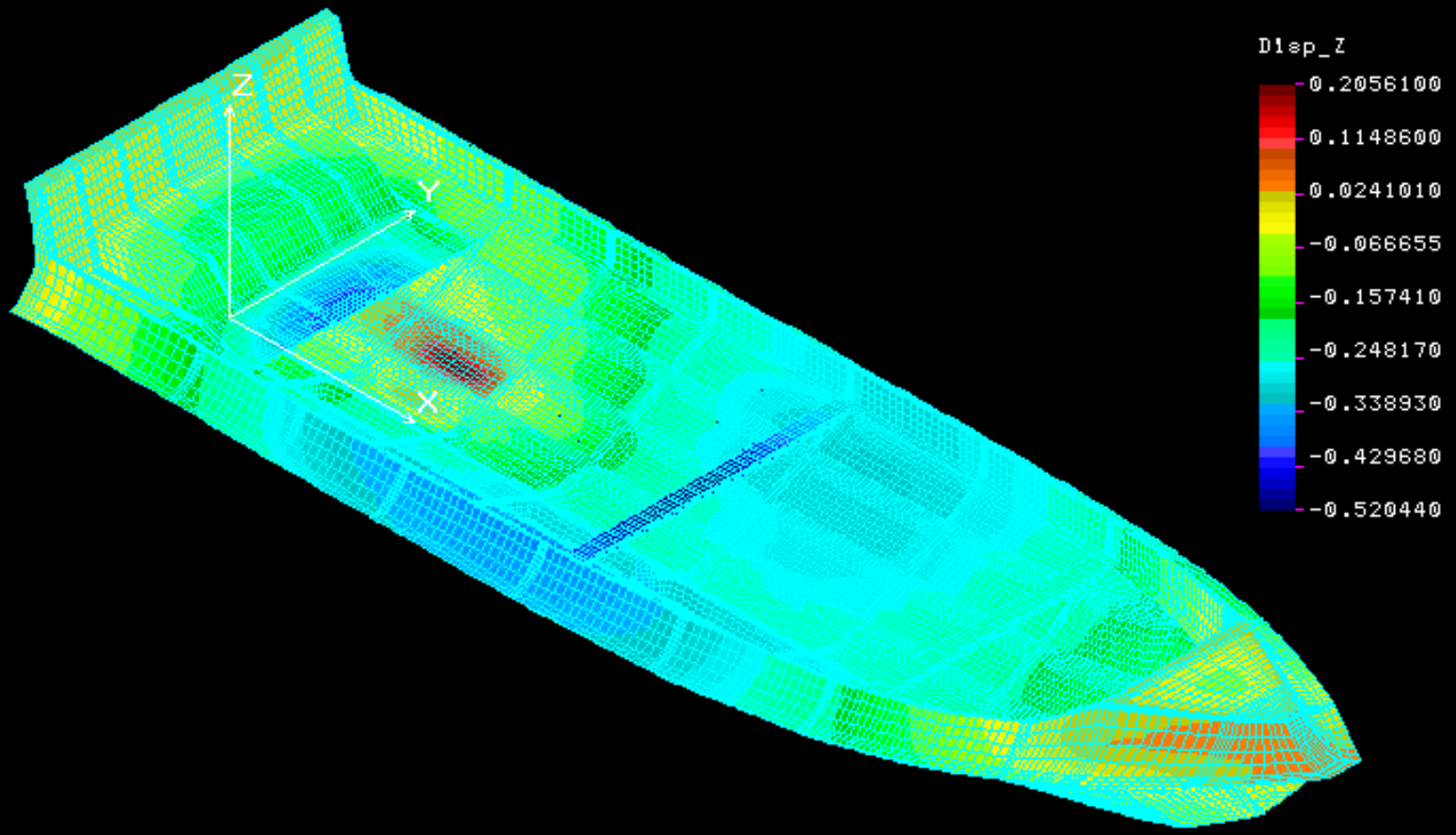
- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

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LC1- AMI-10 psi Pressure Load



LC1- AMI- Z Displacement- Deck



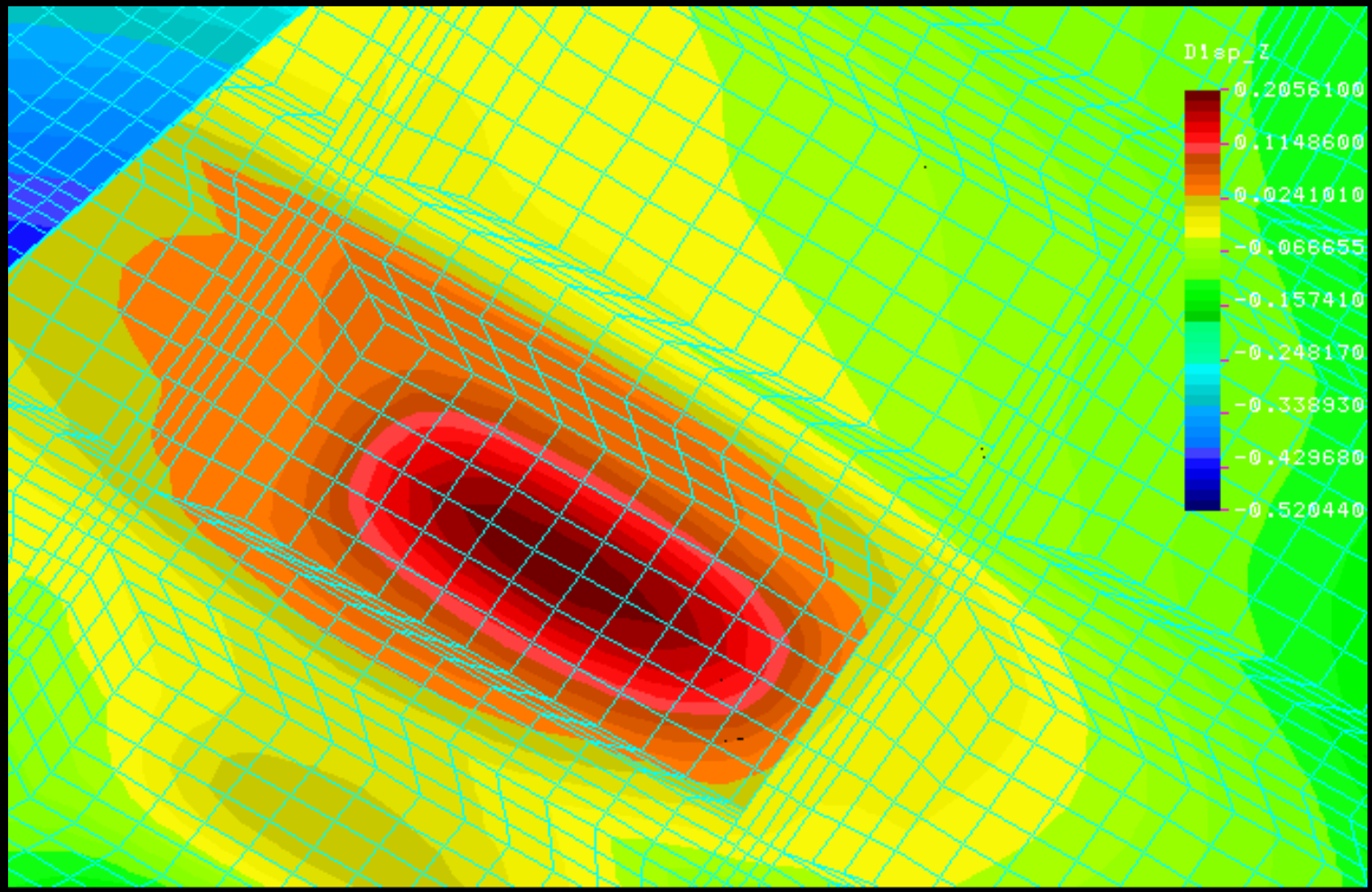
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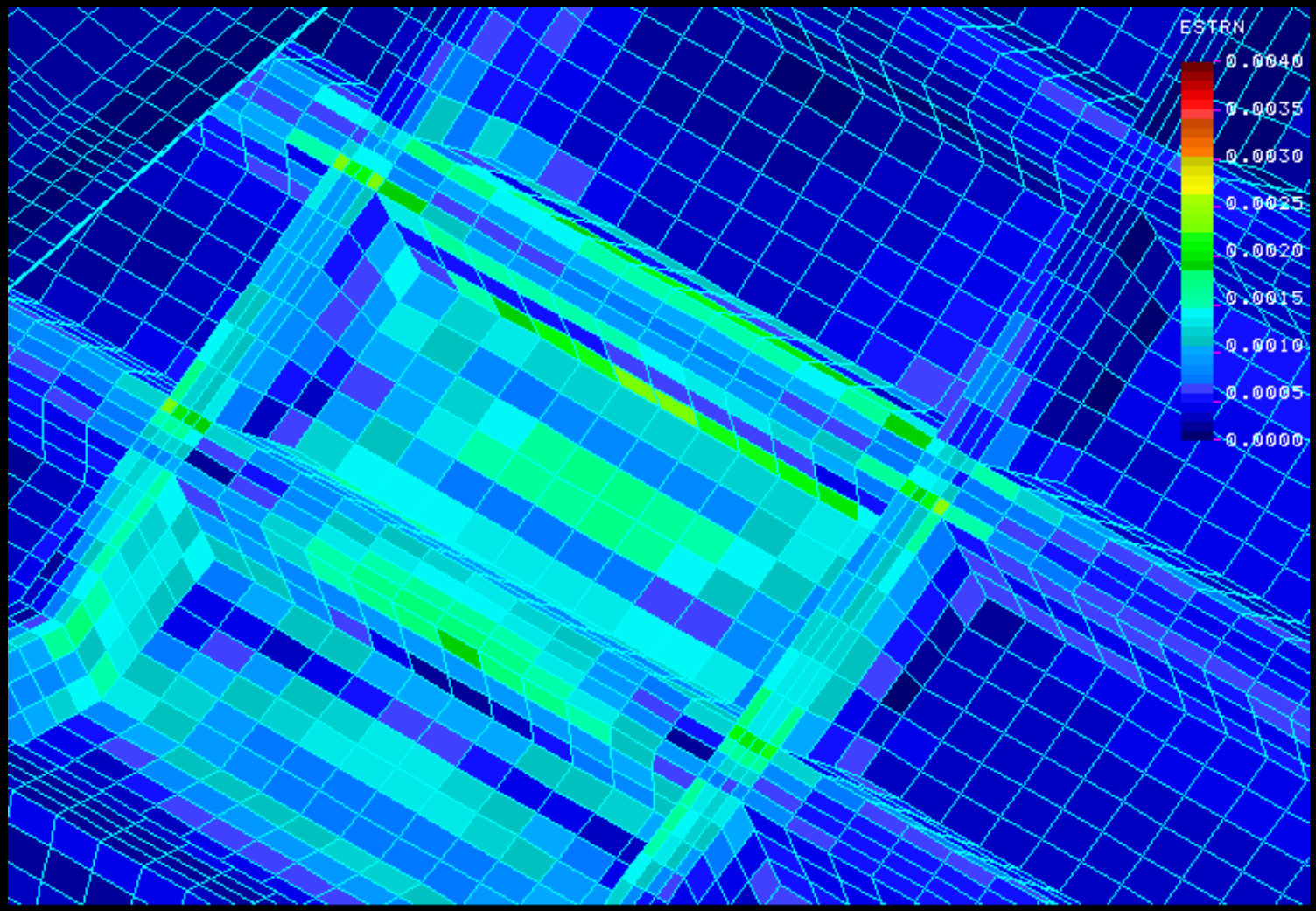
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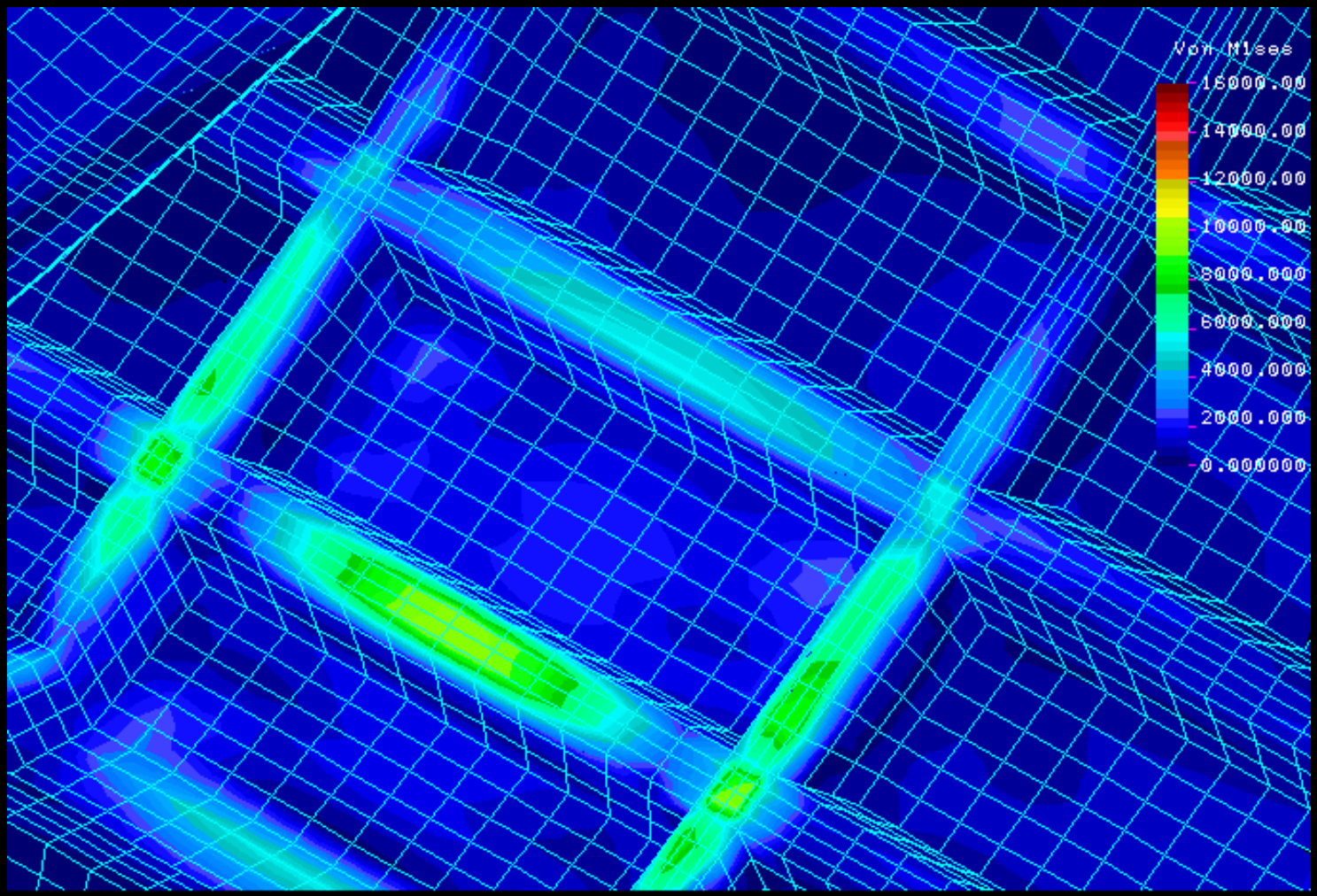
LC1- AMI- Z Displacement- Hull



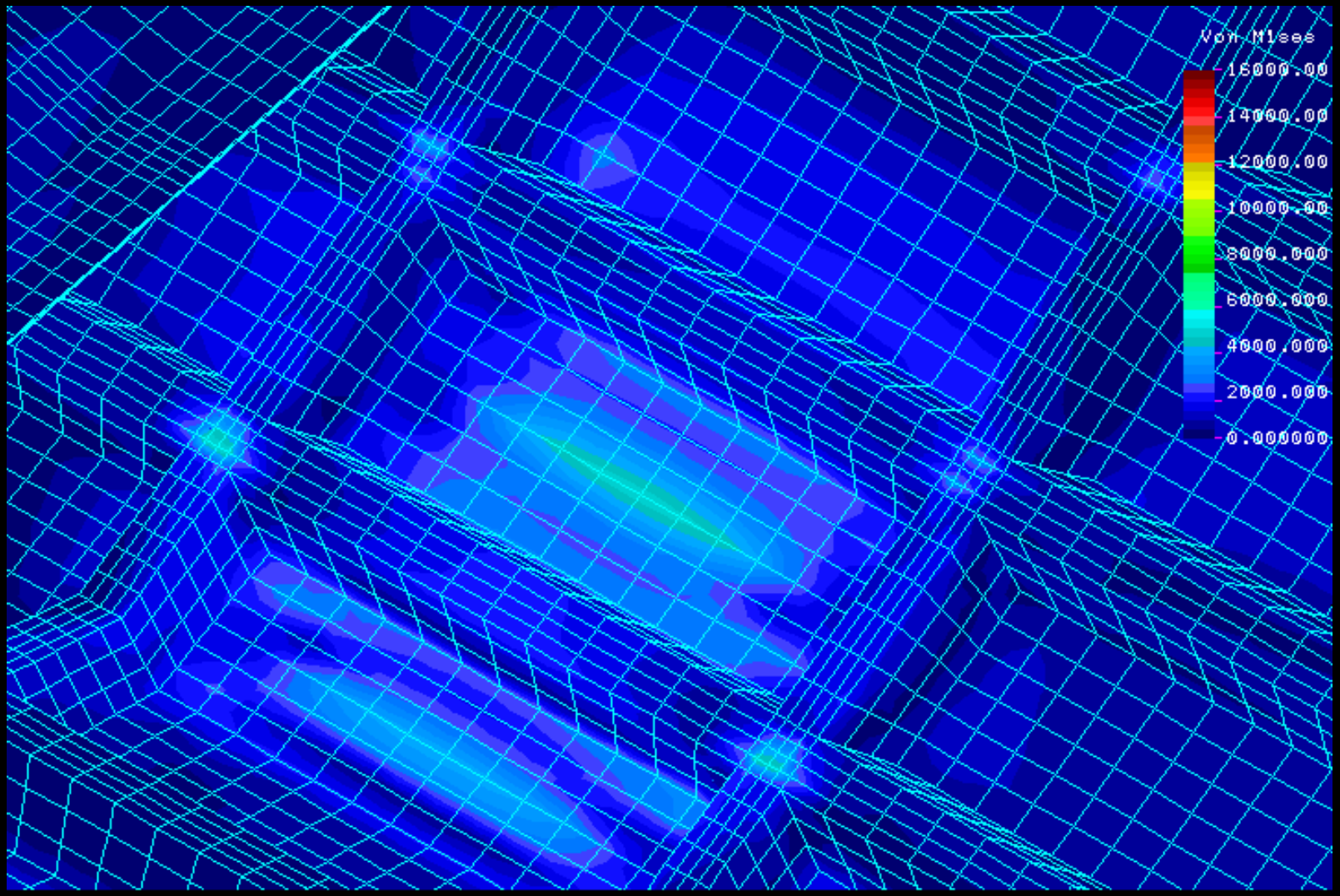
LC1- AMI- Strain



LC1- AMI- Framing Stress



LC1- Hull Shell Stress



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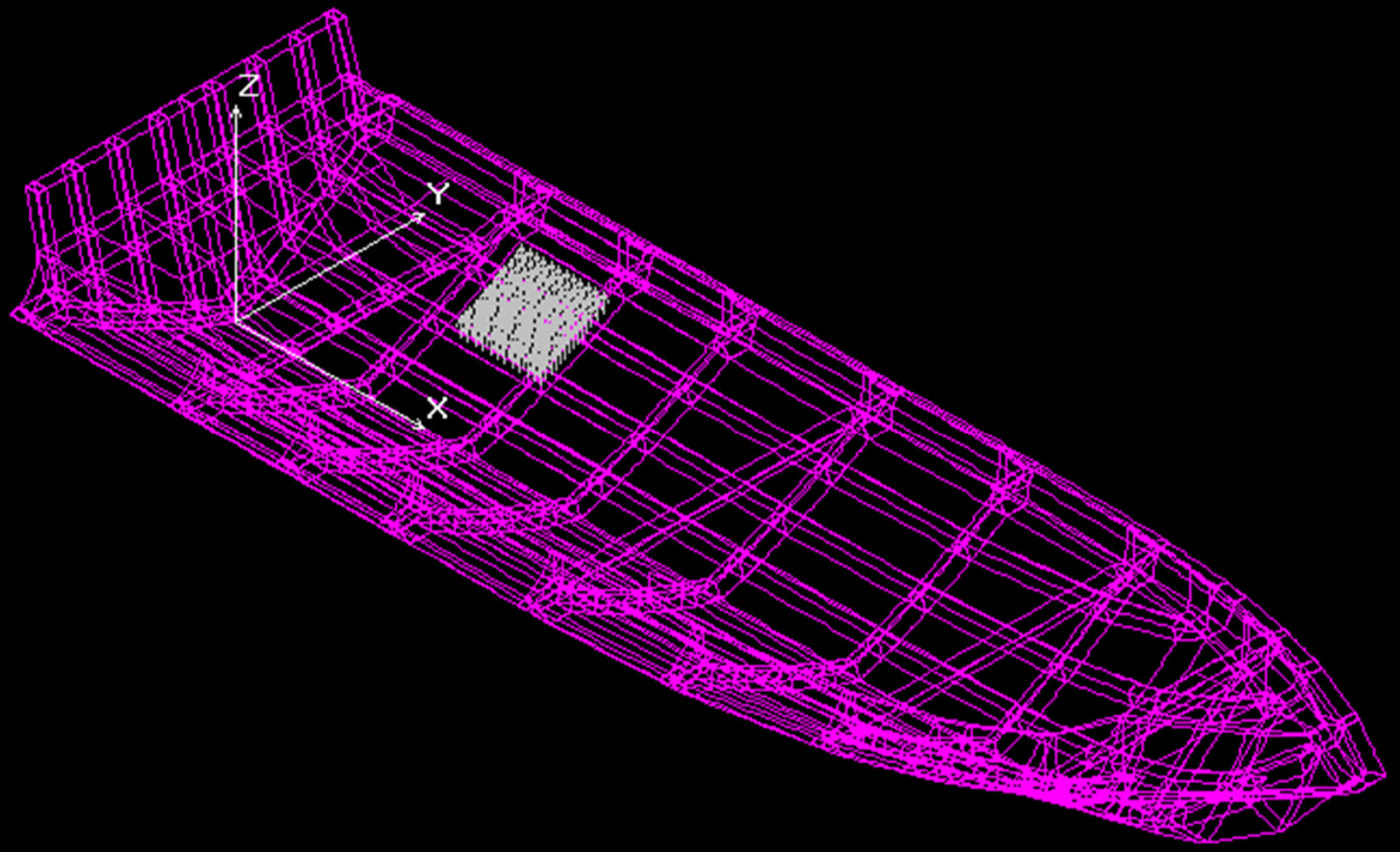
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LC1- AMI- Summary

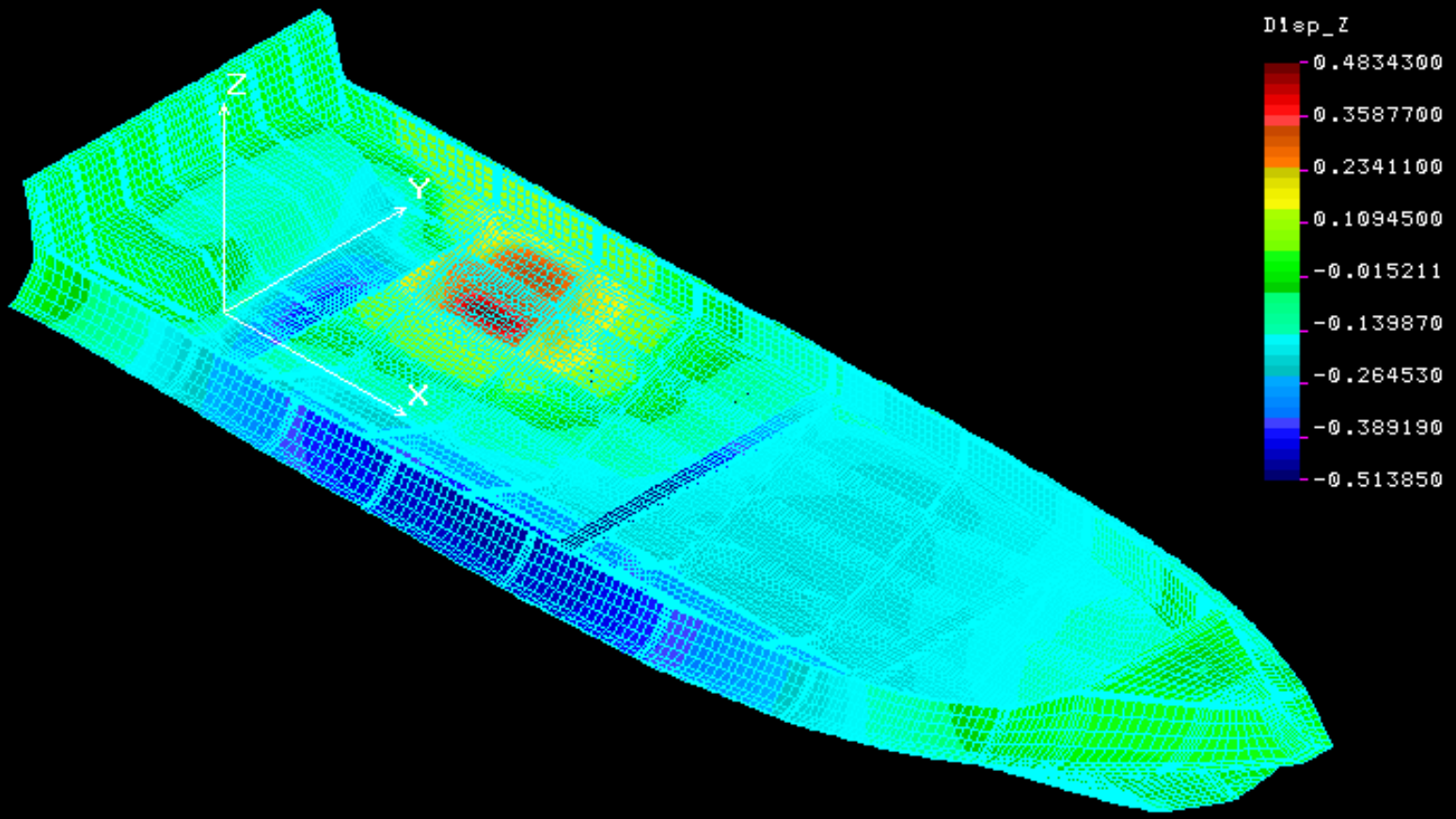
- Hull range of deflection 0.2 to -0.52 in.
- Local panel deflection 0.16 in.
- Maximum strain 0.0028 in/in
- Maximum framing stress 12,000 psi
- Maximum hull shell stress 7,000 psi

LC2- AMO-10 psi Pressure Load



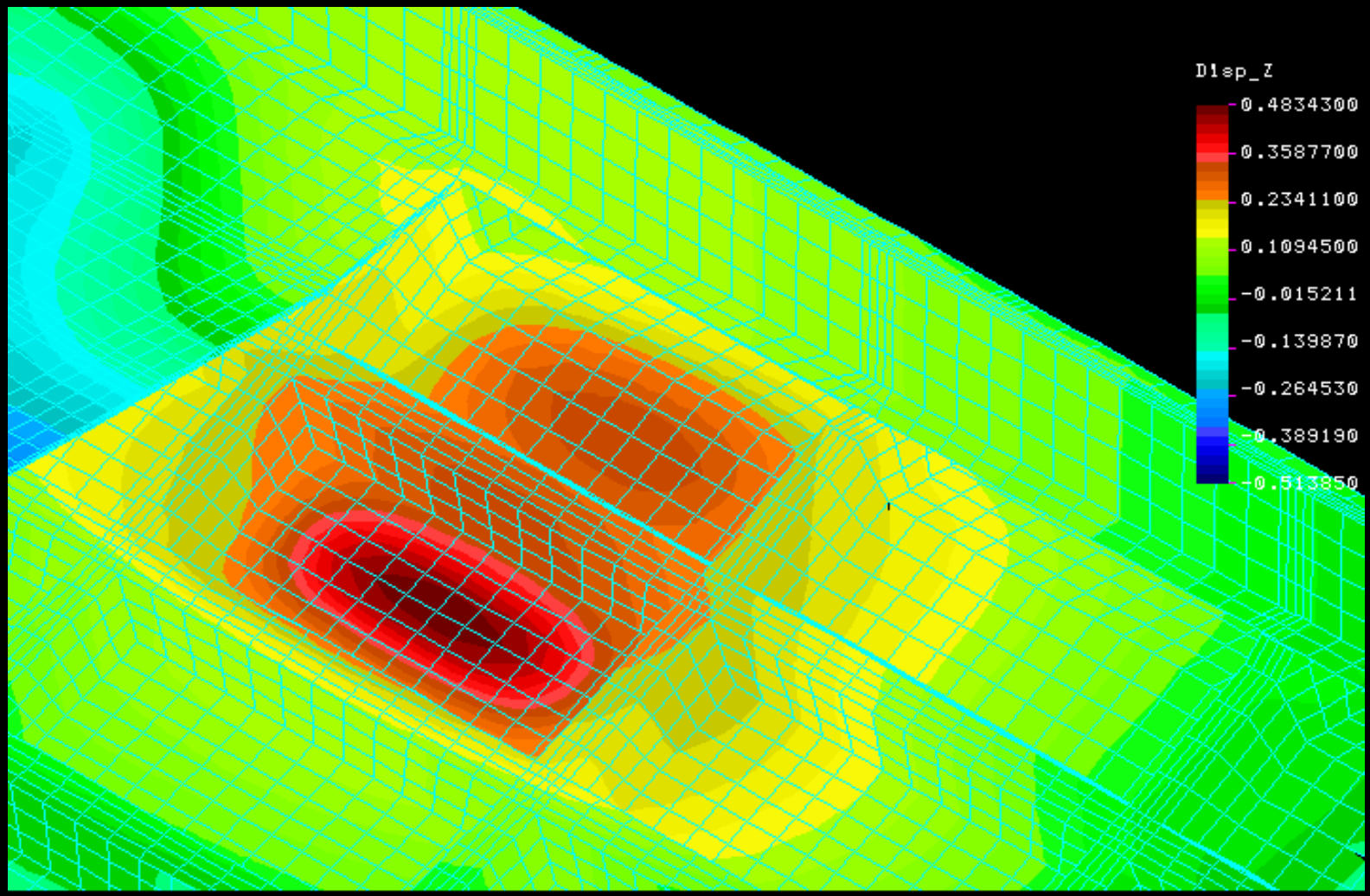
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LC2- AMO- Z Displacement- Deck



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LC2- AMO- Z Displacement- Hull



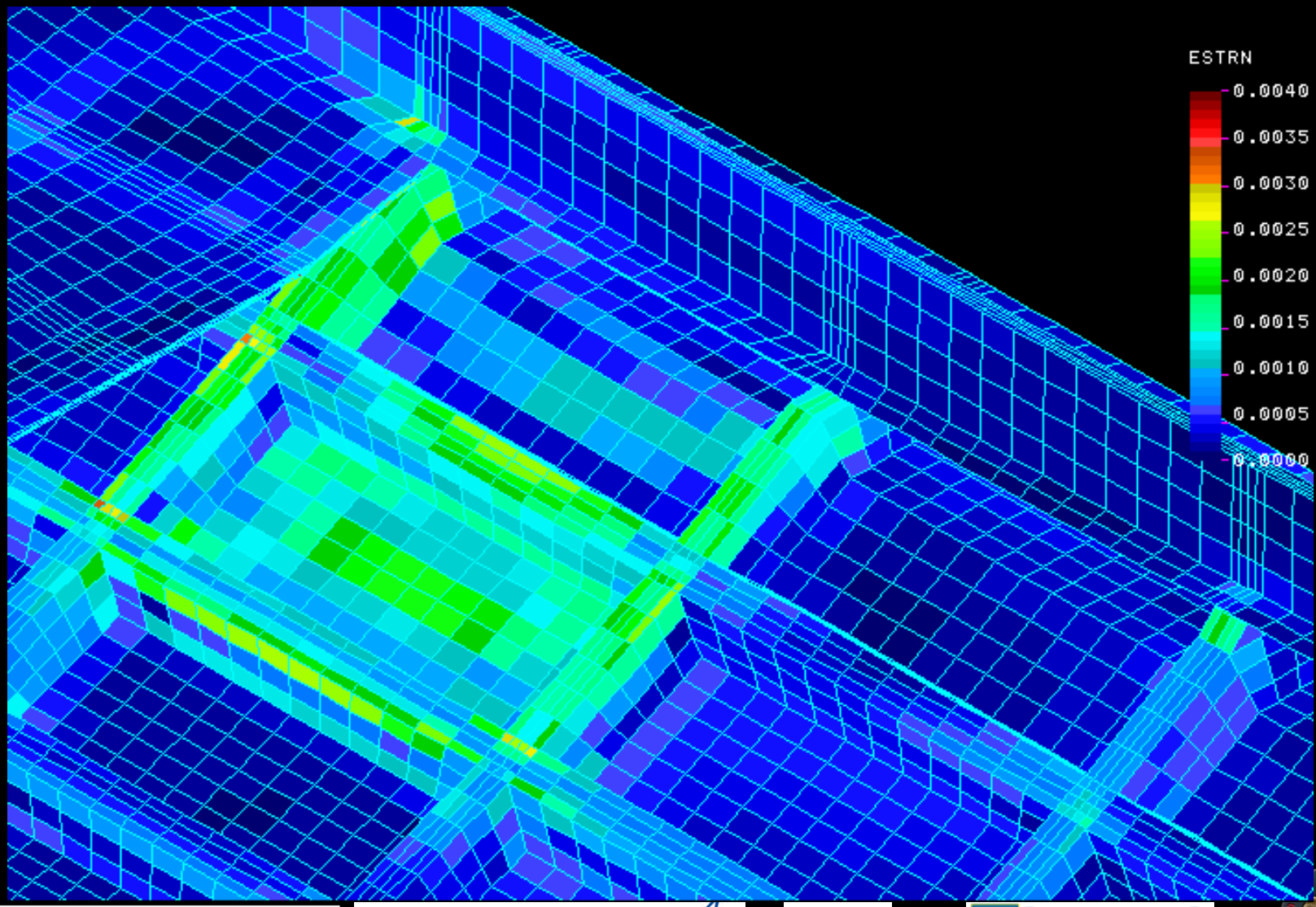
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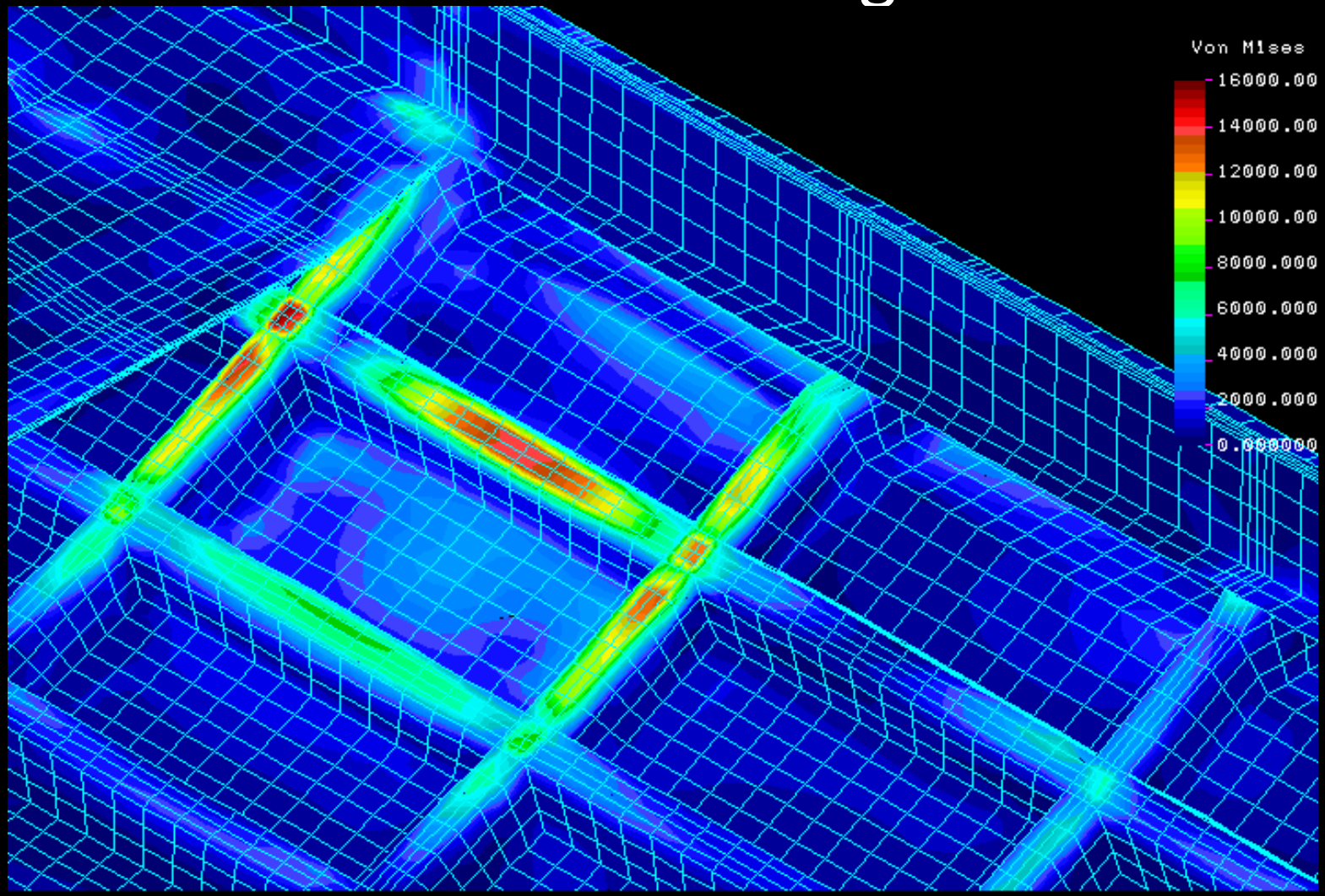
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LC2- AMO- Strain



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LC2- AMO- Framing Stress



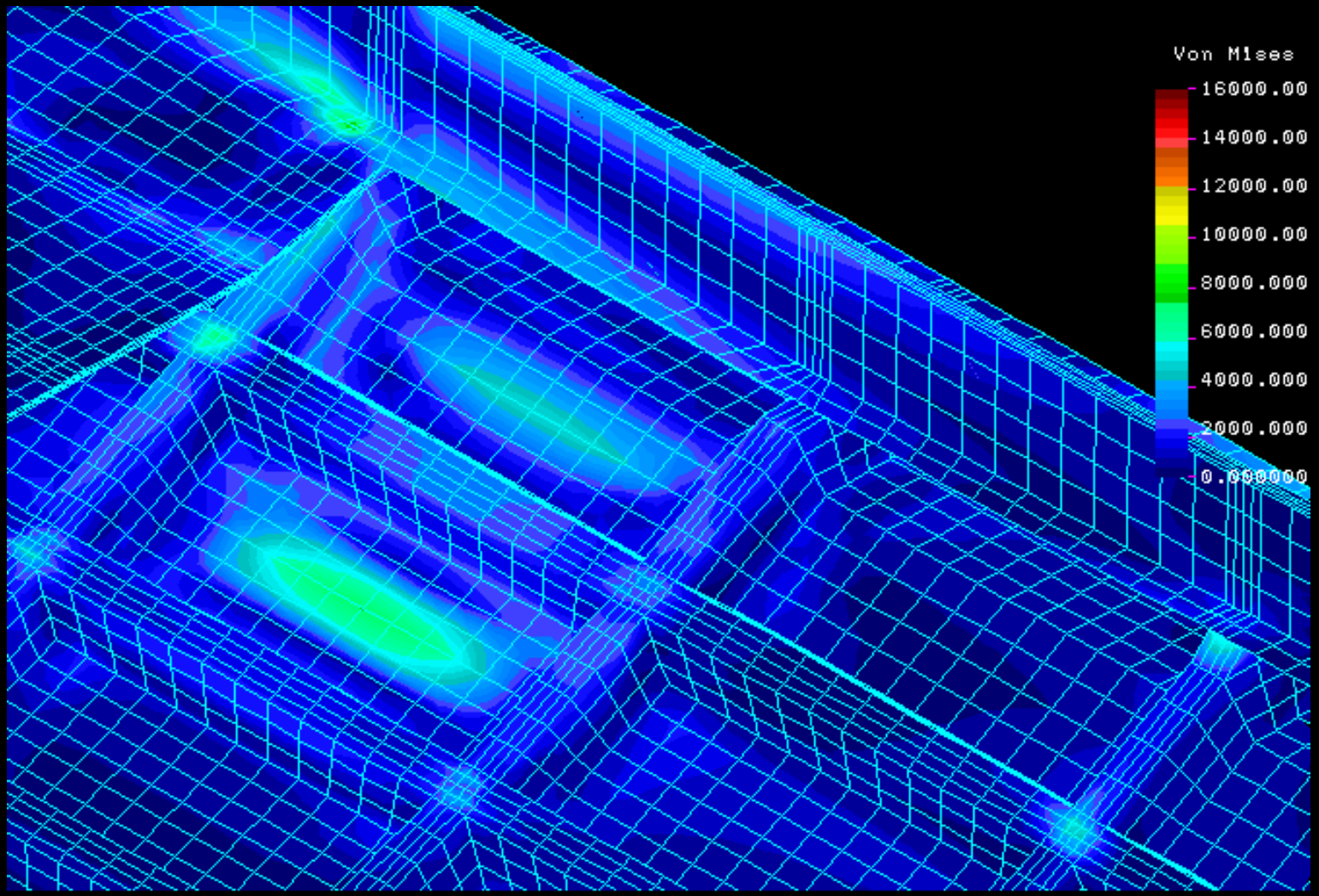
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LC2- AMO- Hull Shell Stress



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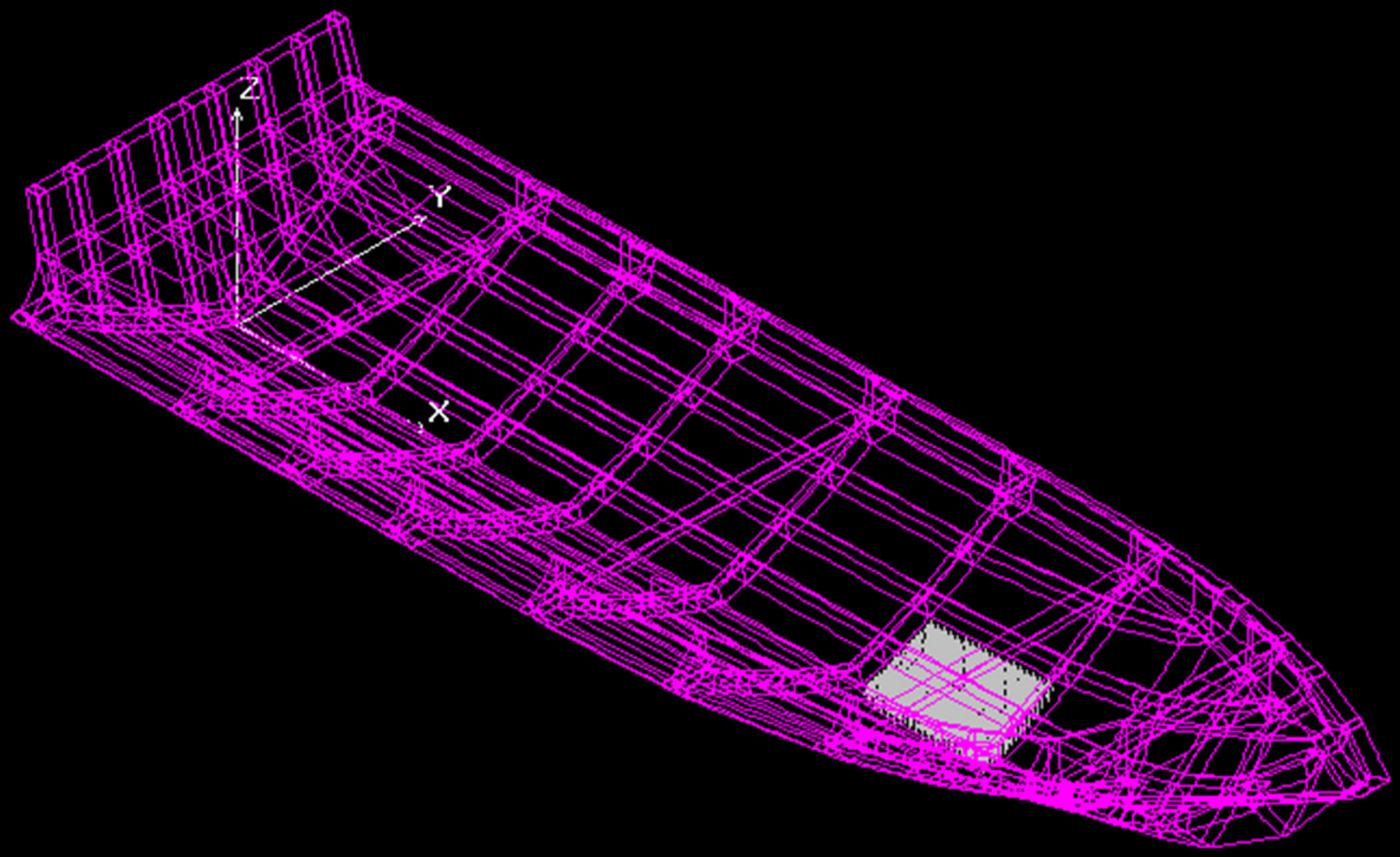
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LC2- AMO- Summary

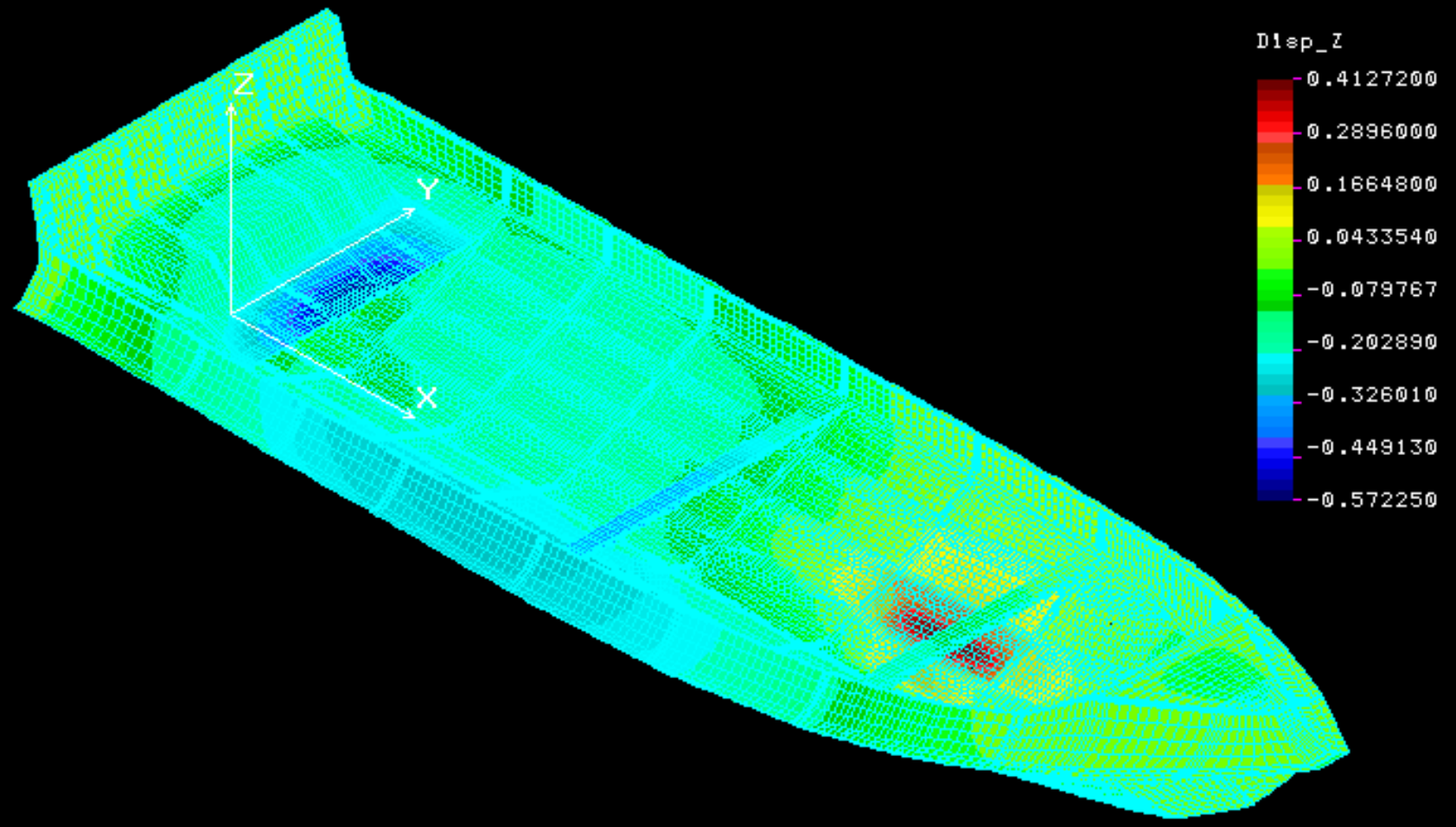
- Hull range of deflection 0.50 to -0.44 in.
- Local panel deflection 0.2 in.
- Maximum strain 0.0030 in/in
- Maximum framing stress 13,000 psi
- Maximum hull shell stress 9,000 psi

LC3- FI-10 psi Pressure Load



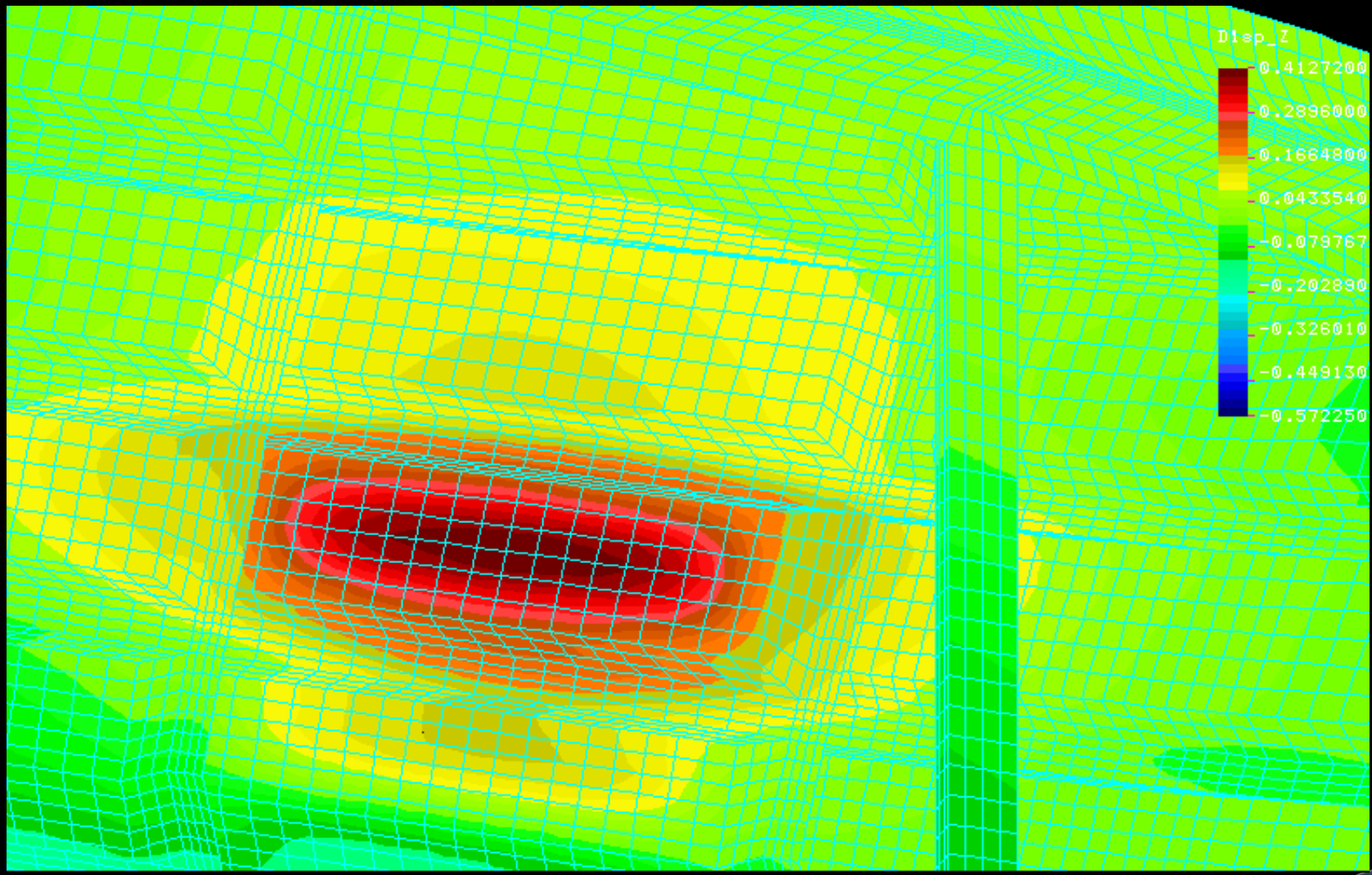
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LC3- FI- Z Displacement - Deck



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LC3- FI- Z Displacement - Hull



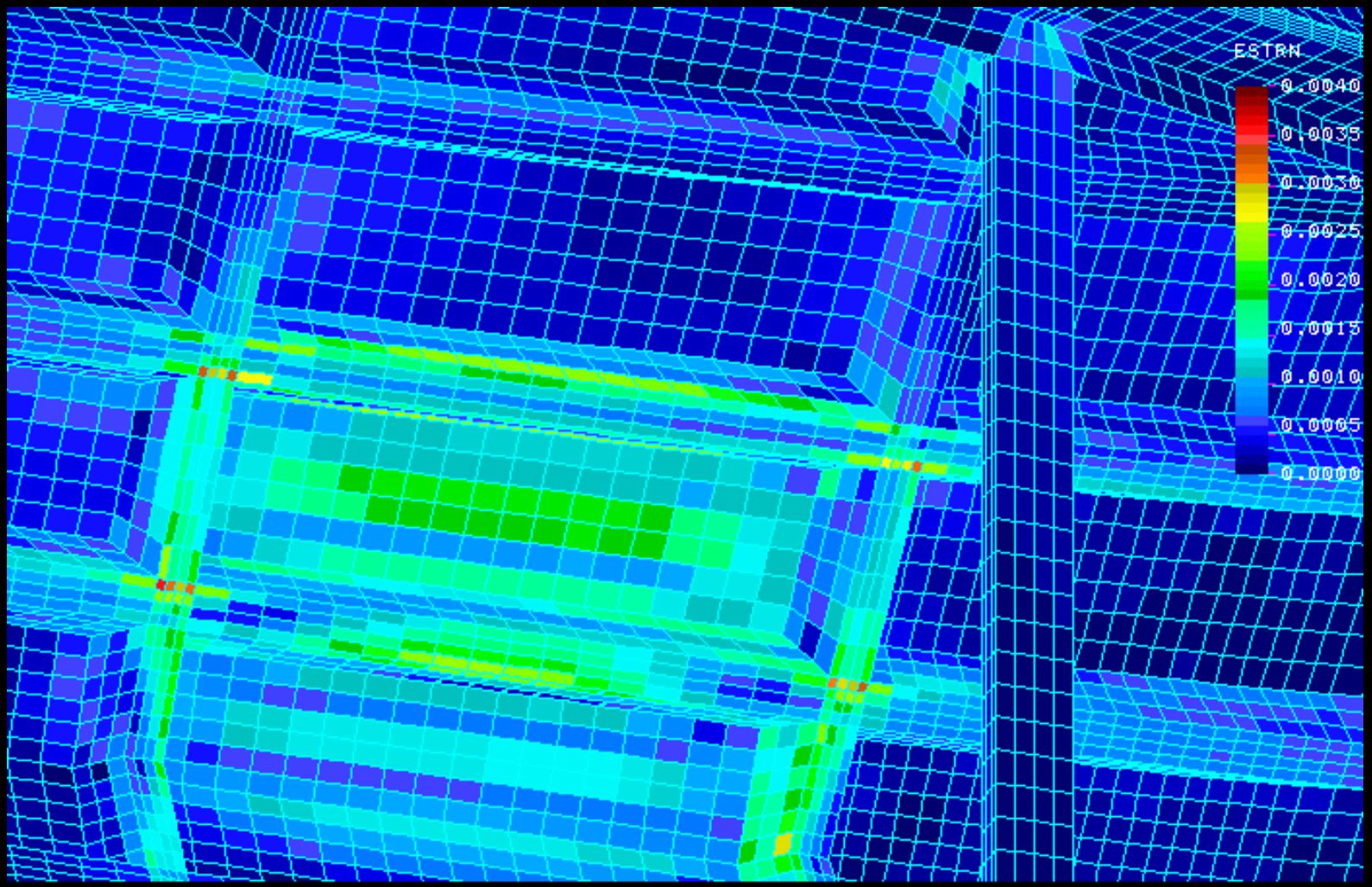
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LC3- FI- Strain



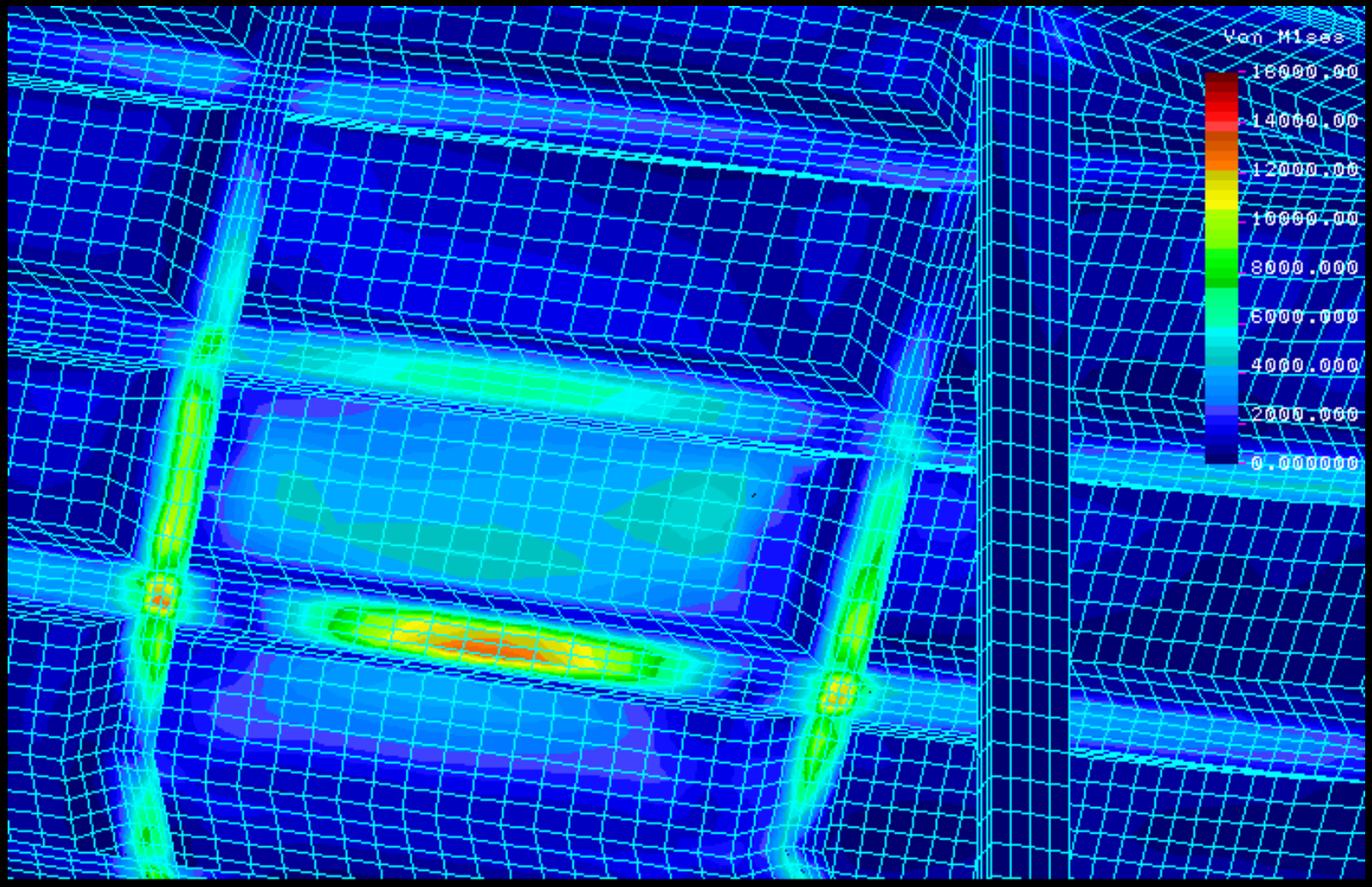
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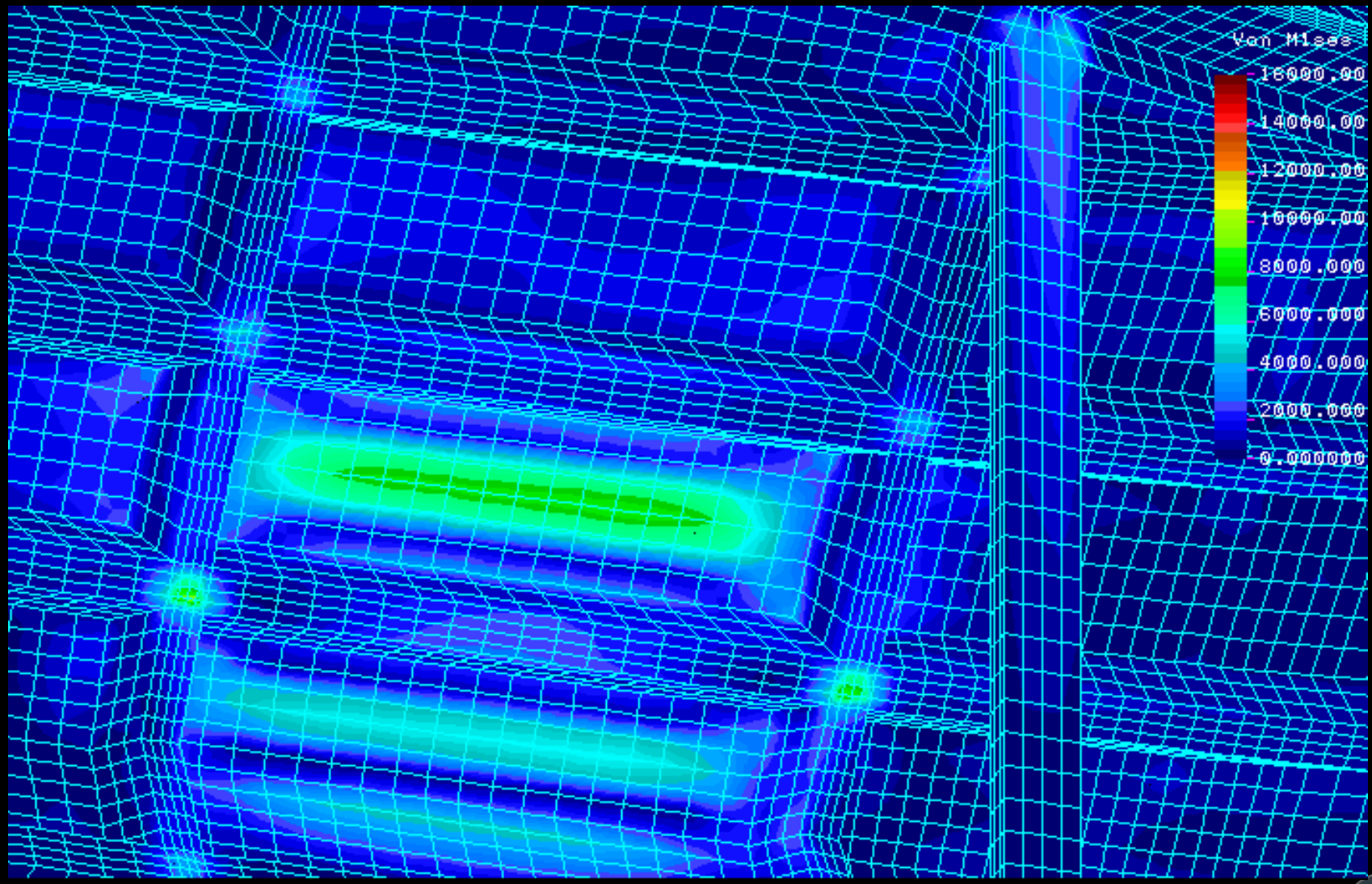
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LC3- FI- Framing Stress



LC3- FI- Hull Shell Stress



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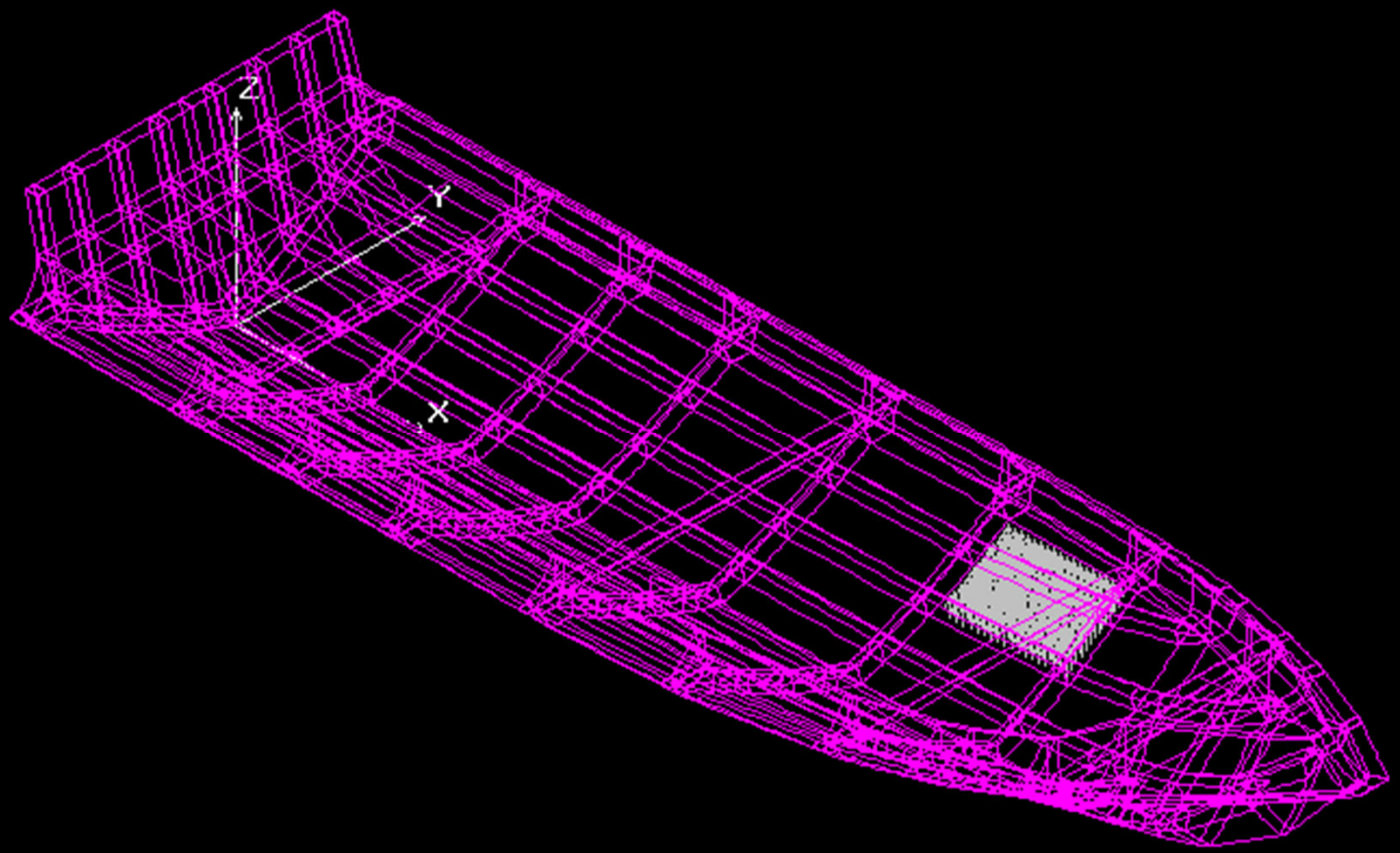
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LC3- FI- Summary

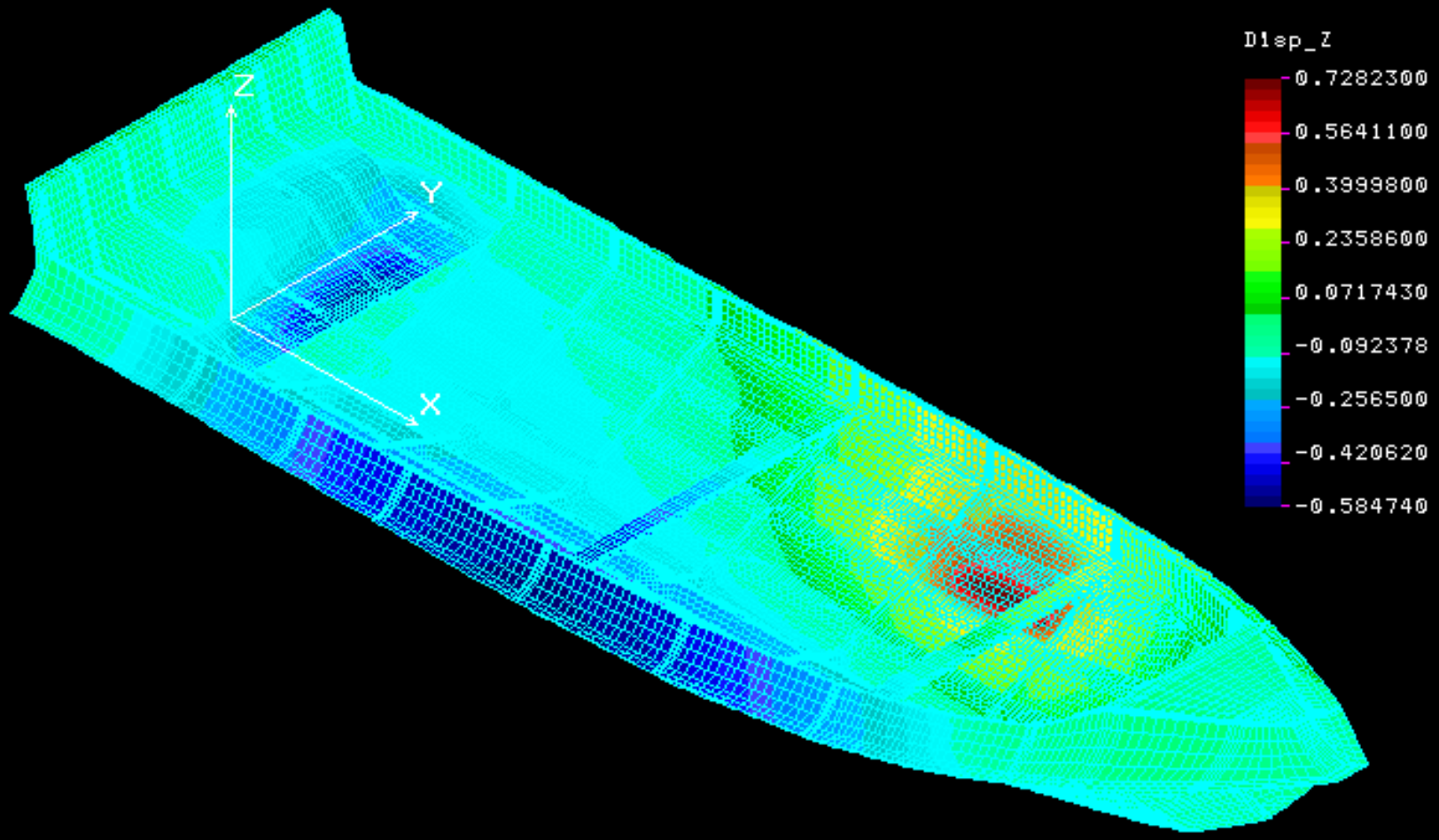
- Hull range of deflection 0.41 to -0.57 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.0030 in/in
- Maximum framing stress 13,000 psi
- Maximum hull shell stress 8,000 psi

LC4- FO-10 psi Pressure Load

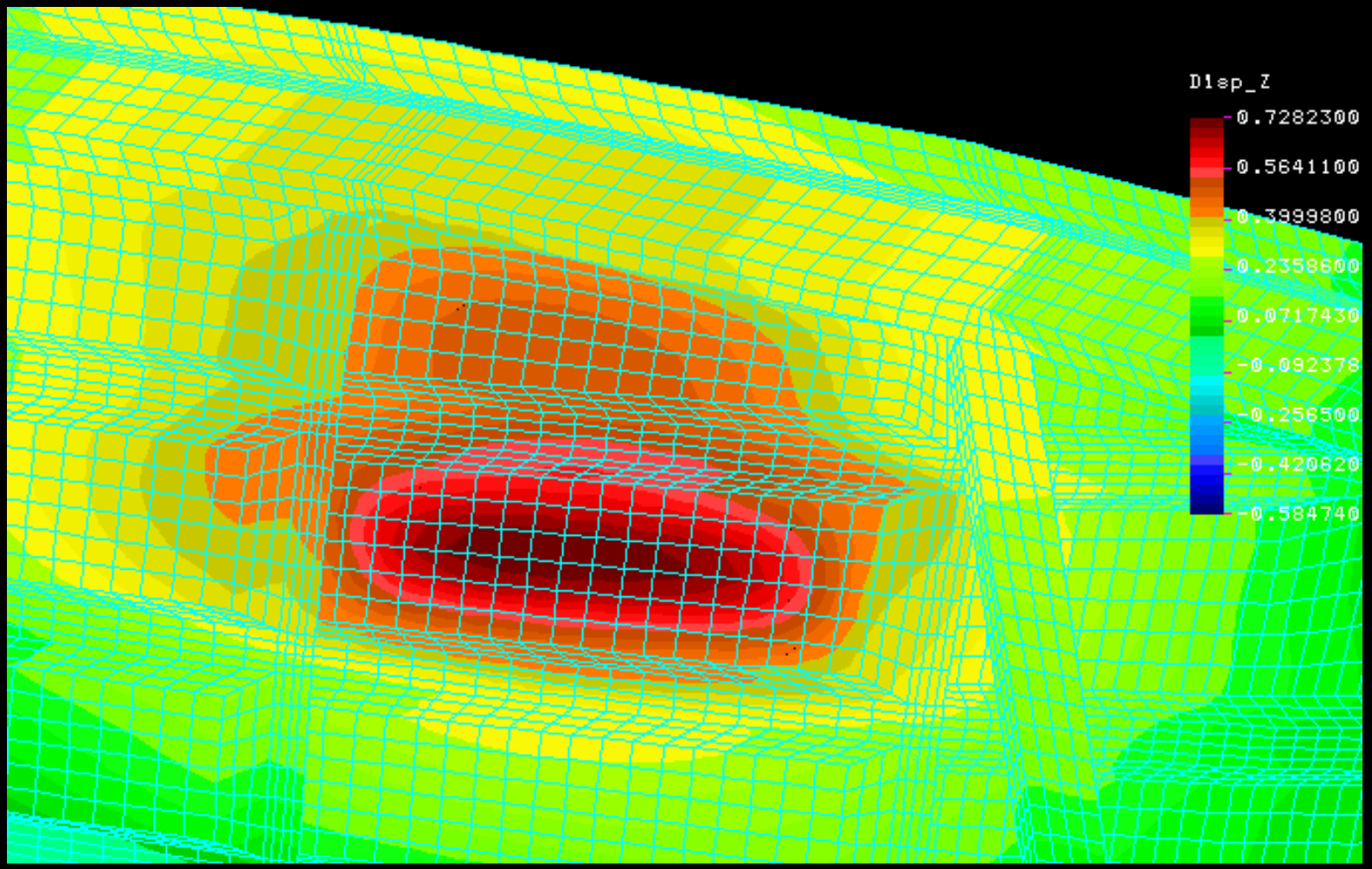


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LC4- FO- Z Displacement- Deck



LC4- FO- Z Displacement- Hull



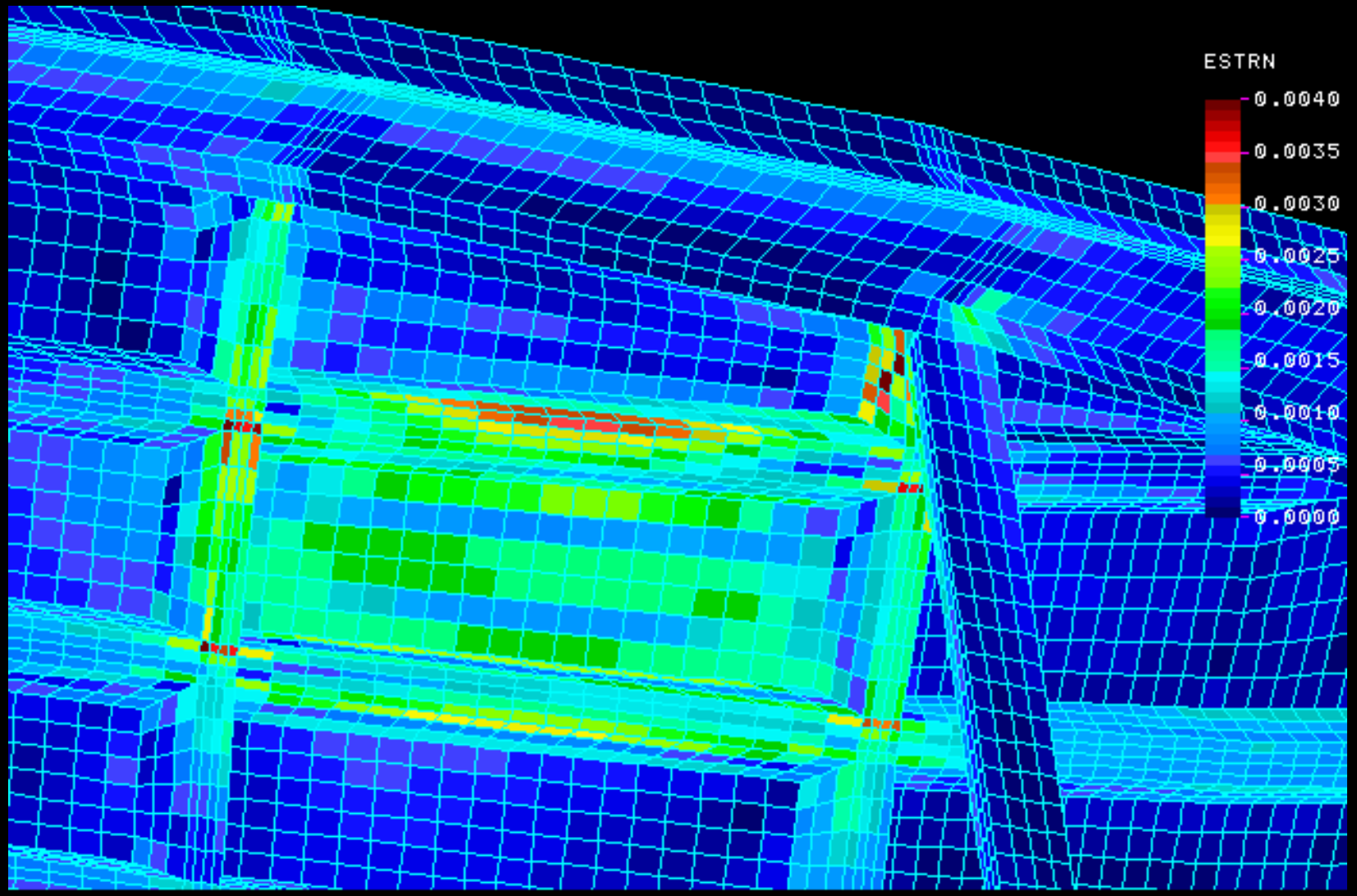
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LC4- FO- Strain



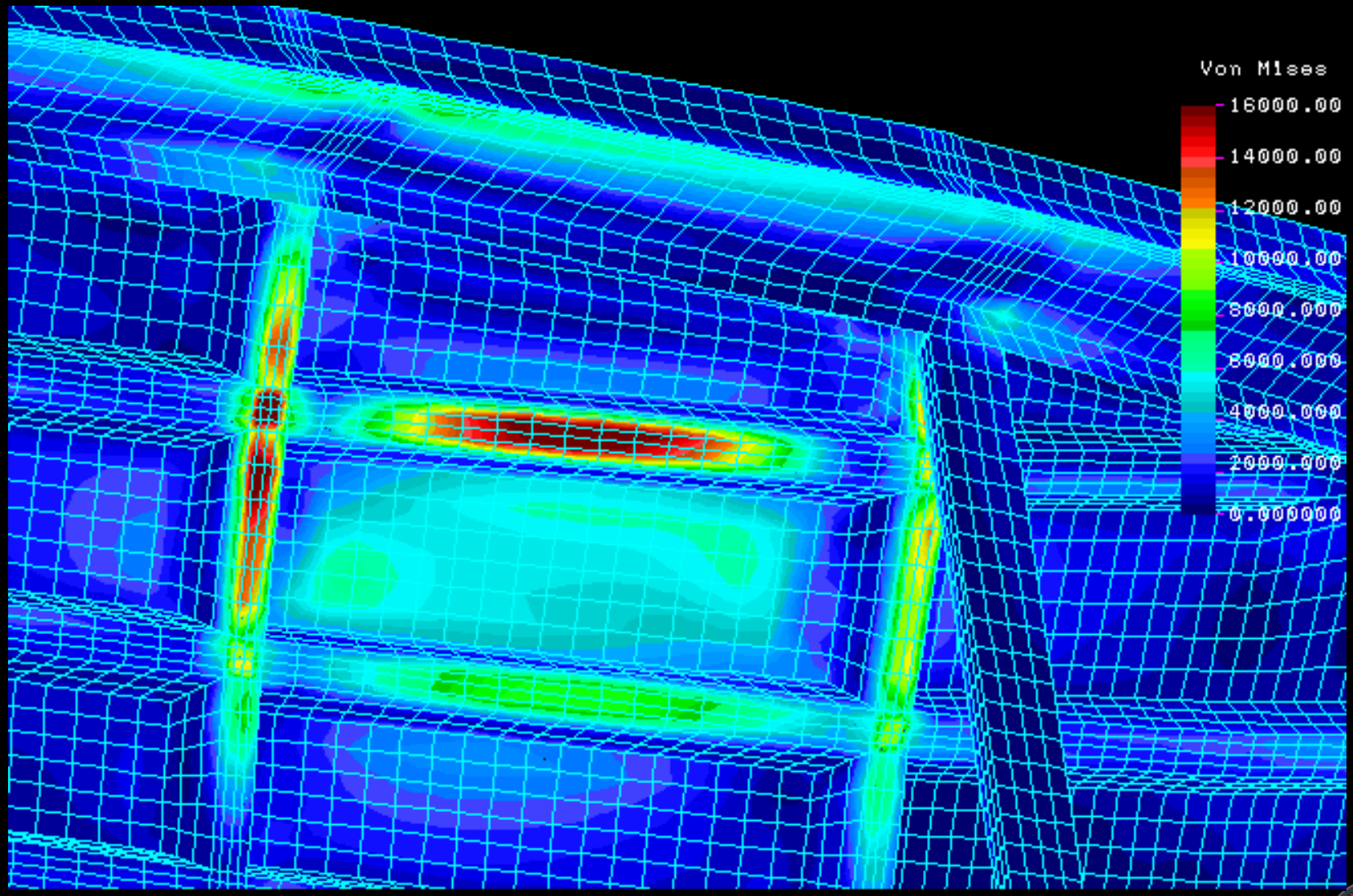
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LC4- FO- Framing Stress



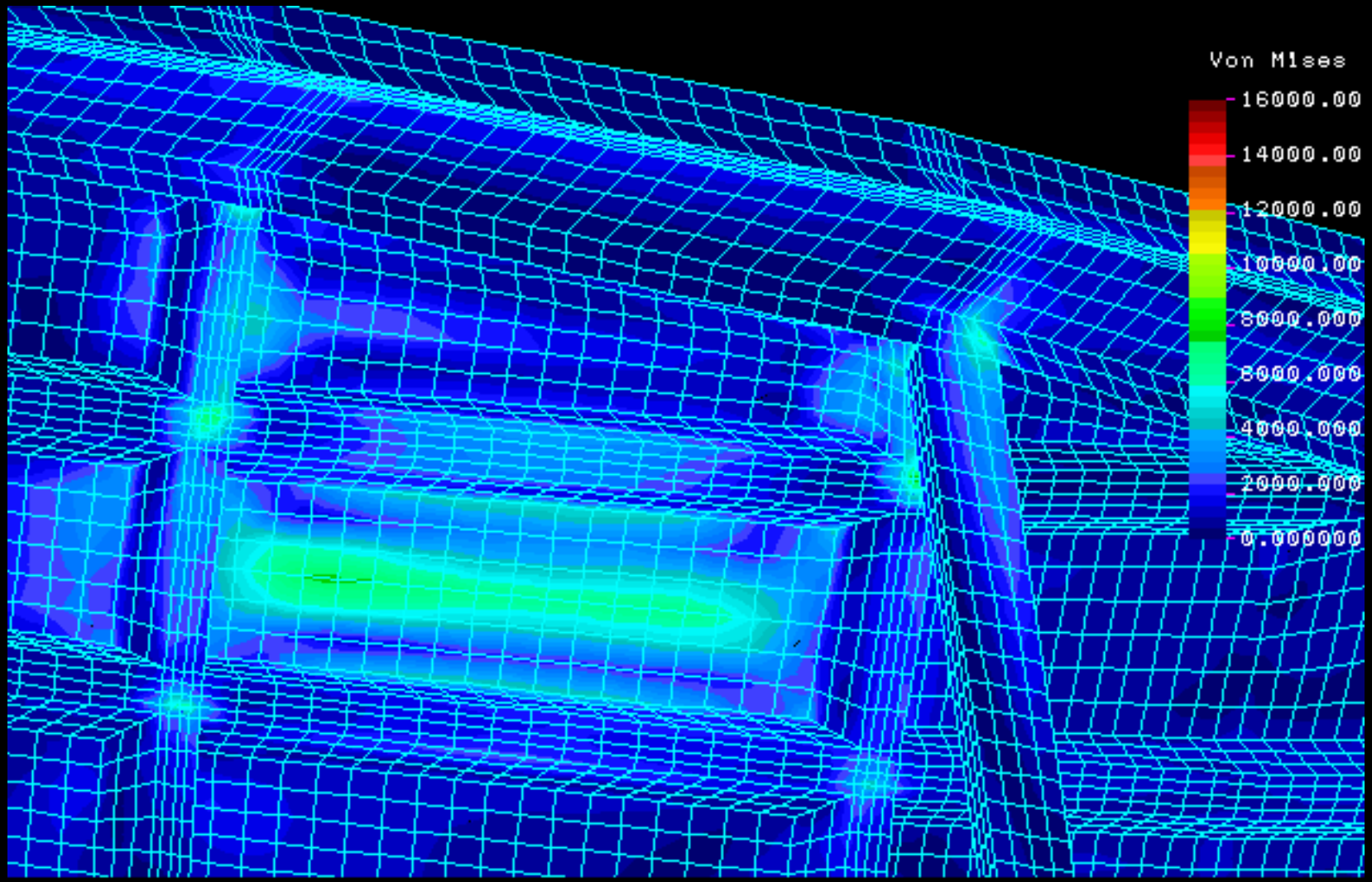
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LC4- FO- Hull Shell Stress



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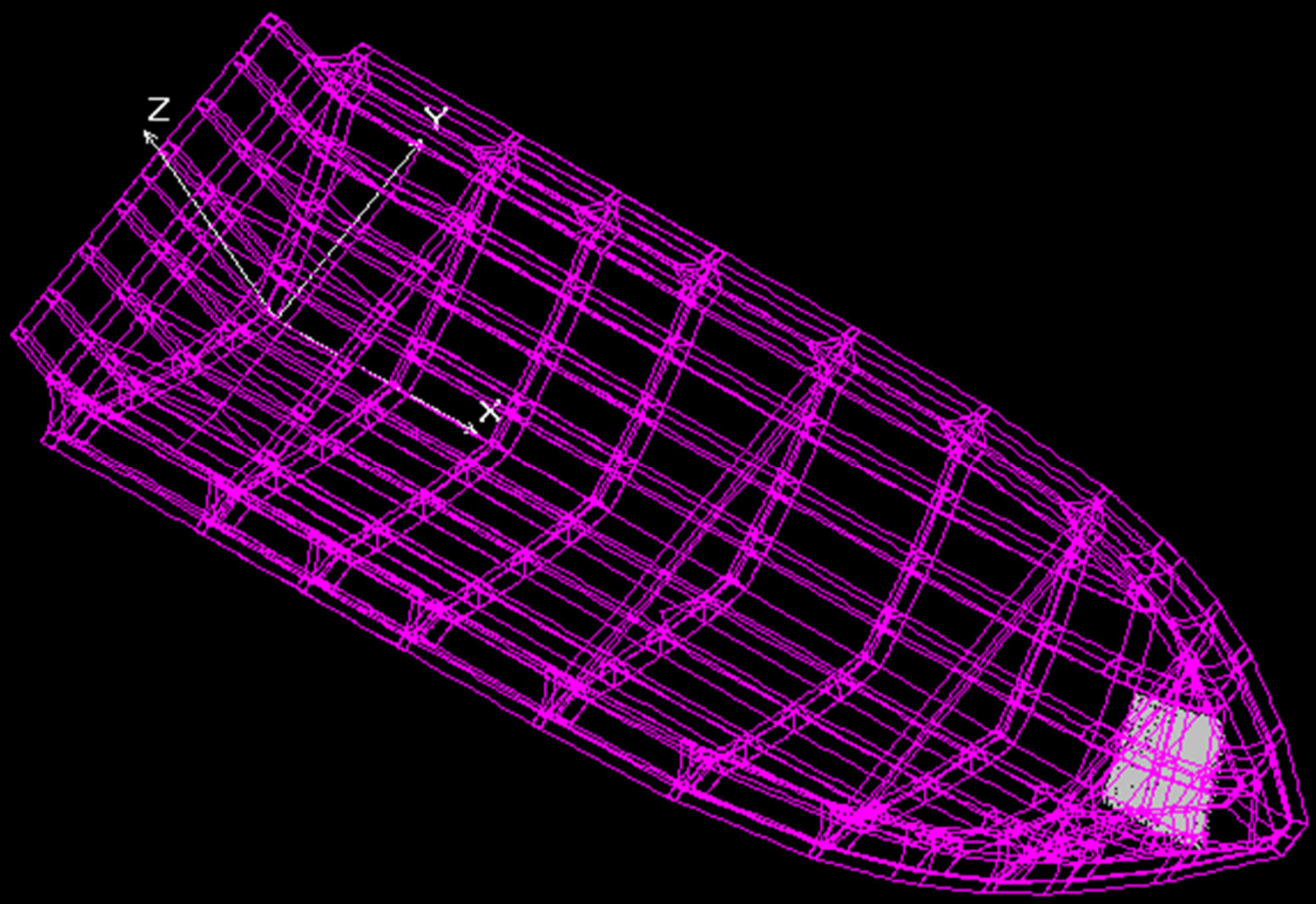
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LC4- FO- Summary

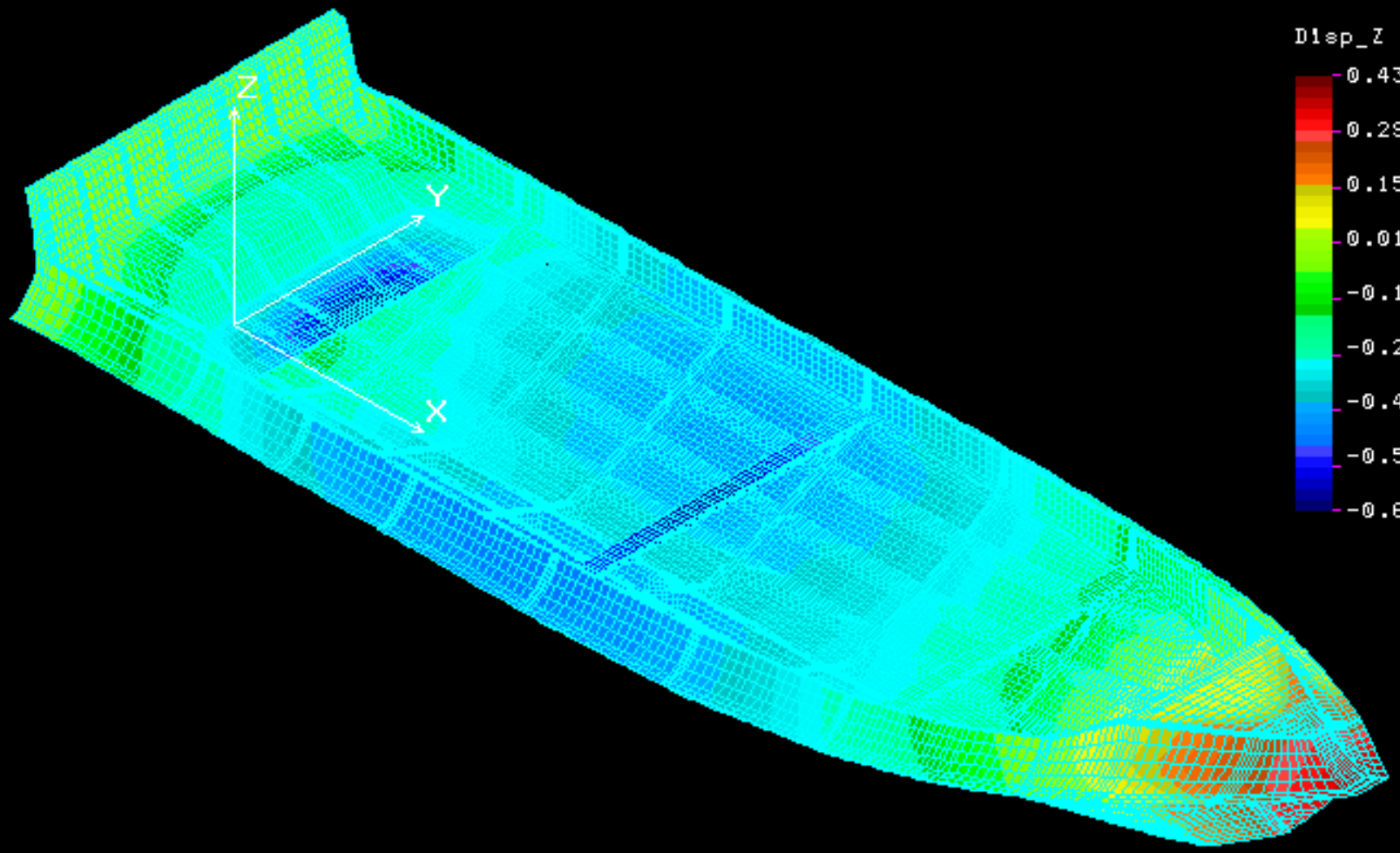
- Hull range of deflection 0.73 to -0.58 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.0035 in/in
- Maximum framing stress 16,000 psi
- Maximum hull shell stress 7,000 psi

LC5- STR-10 psi Pressure Load



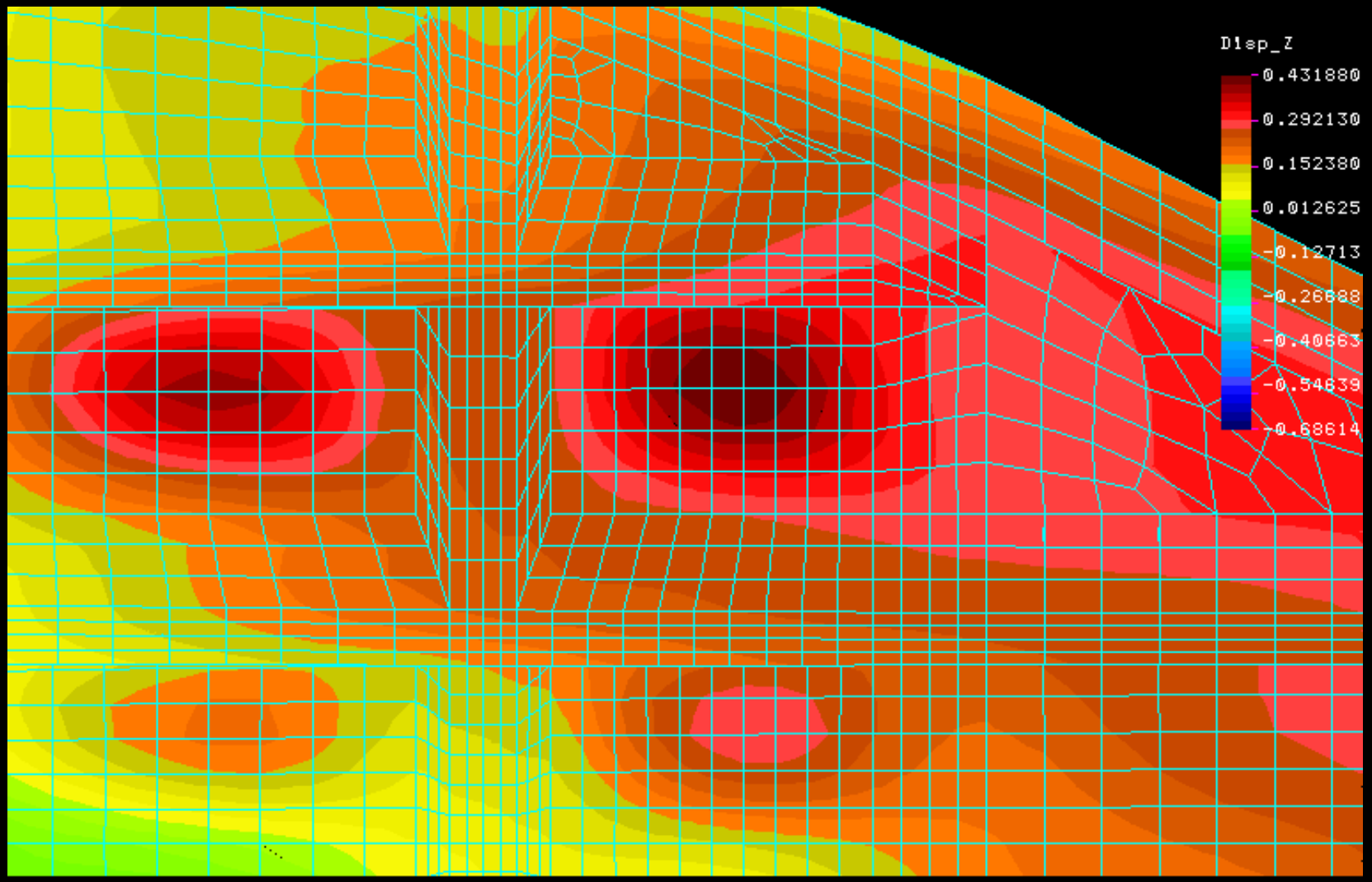
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LC5- STR- Z Displacement - Deck



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LC5- STR- Z Displacement - Hull



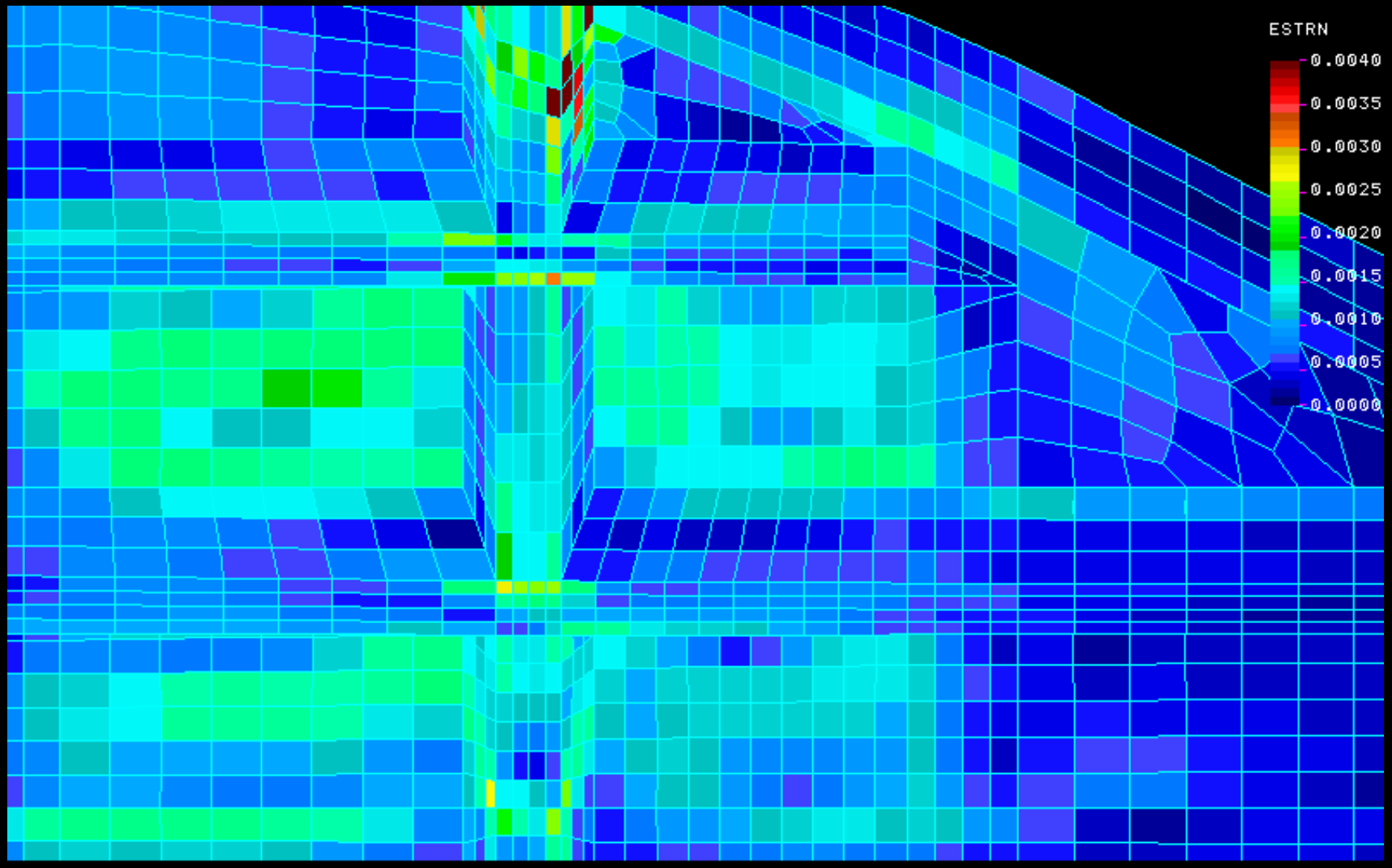
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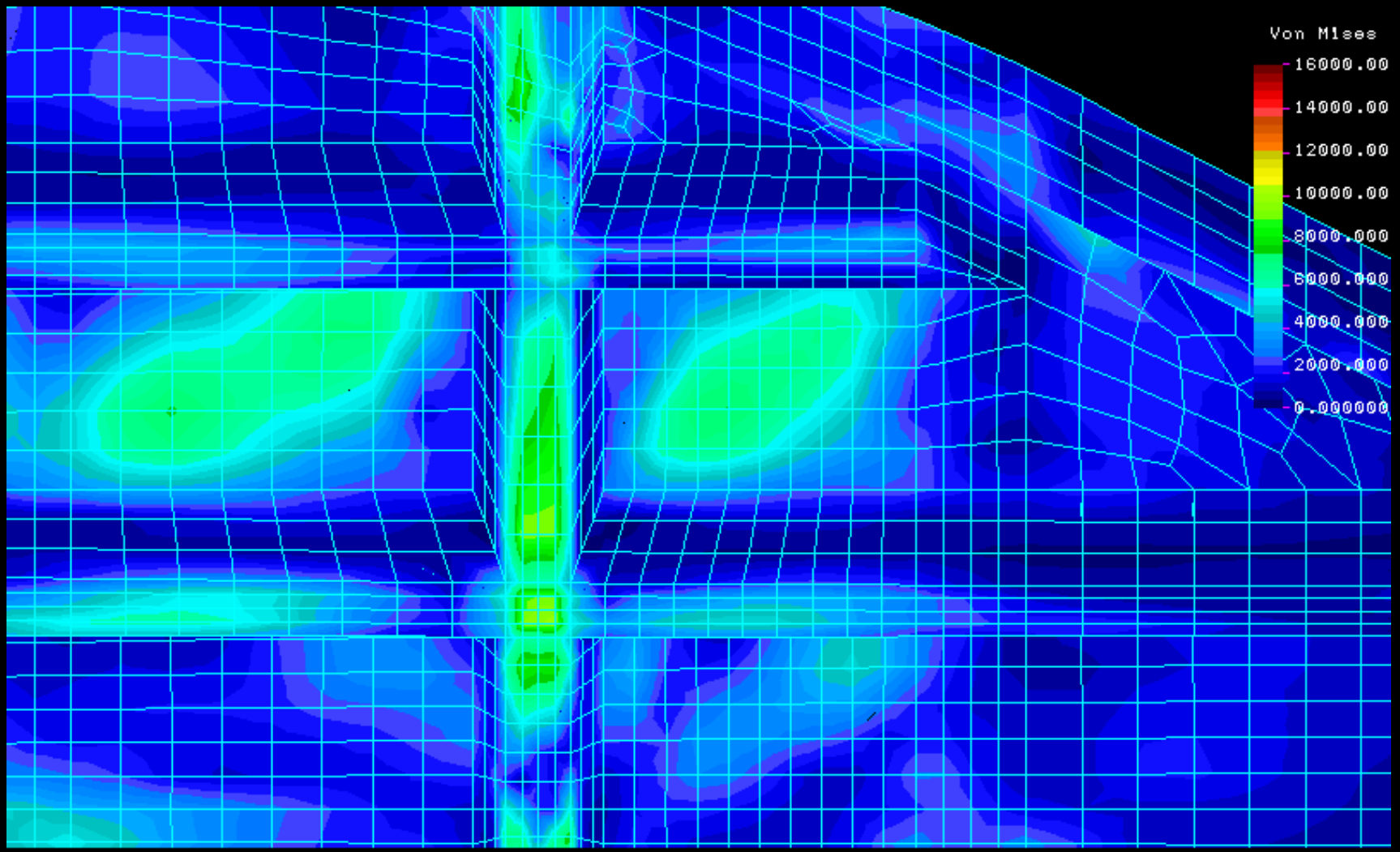
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LC5- STR- Strain



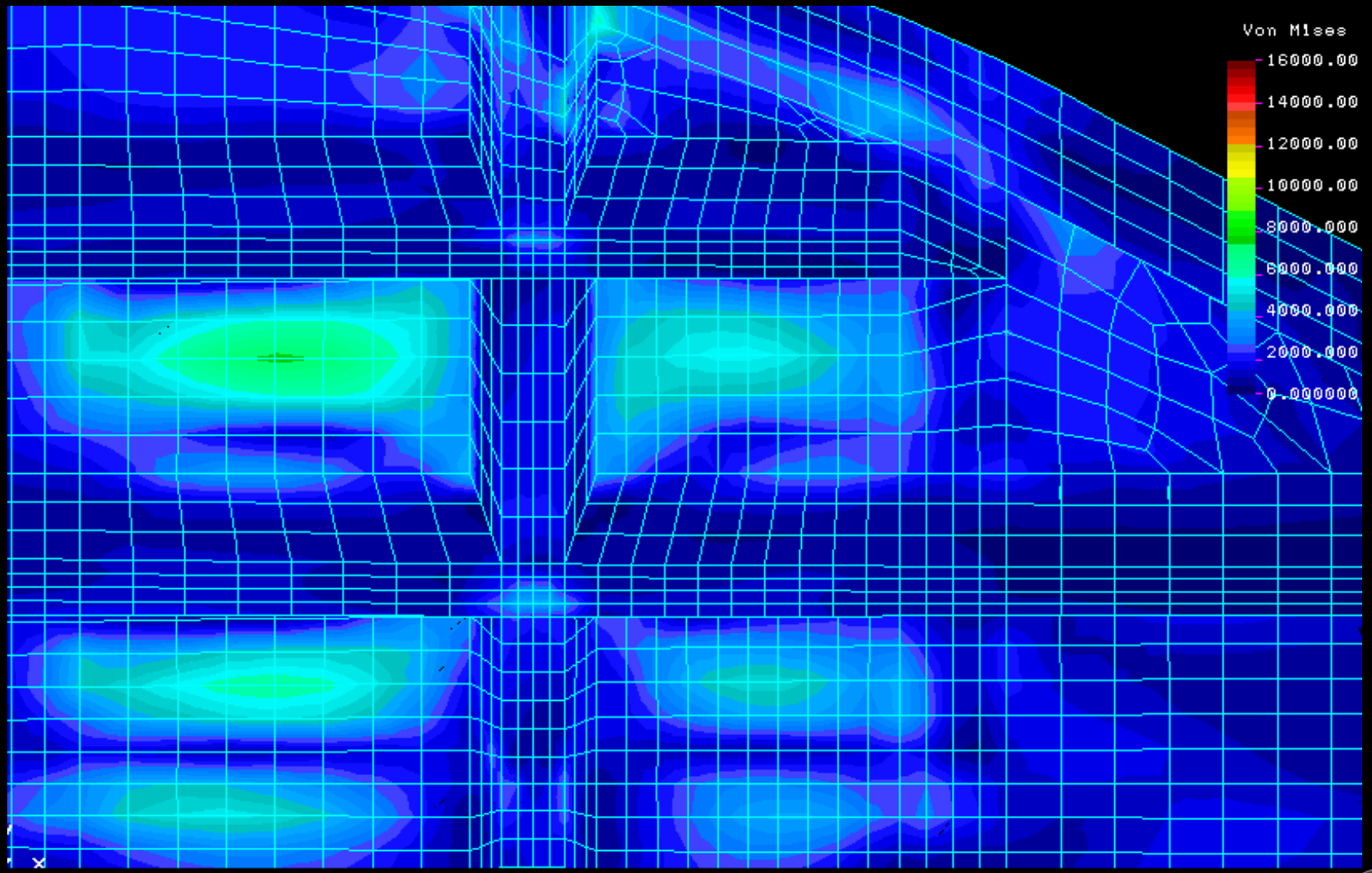
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LC5- STR- Framing Stress



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LC5- STR- Hull Shell Stress



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LC5- STR- Summary

- Hull range of deflection 0.43 to -0.69 in.
- Local panel deflection 0.22 in.
- Maximum strain 0.0030 in/in
- Maximum framing stress 12,000 psi
- Maximum hull shell stress 7,000 psi

LC(1-5)- SAS Summary

Range of maximum values in SAS cases

- Hull range of deflection 1.07 to -0.69 in.
- Local panel deflection 0.16 to 0.25 in.
- Maximum strain 0.0028 to 0.0035 in/in
- Max framing stress 12,000 to 19,000 psi
- Max hull shell stress 7,000 to 9,000 psi

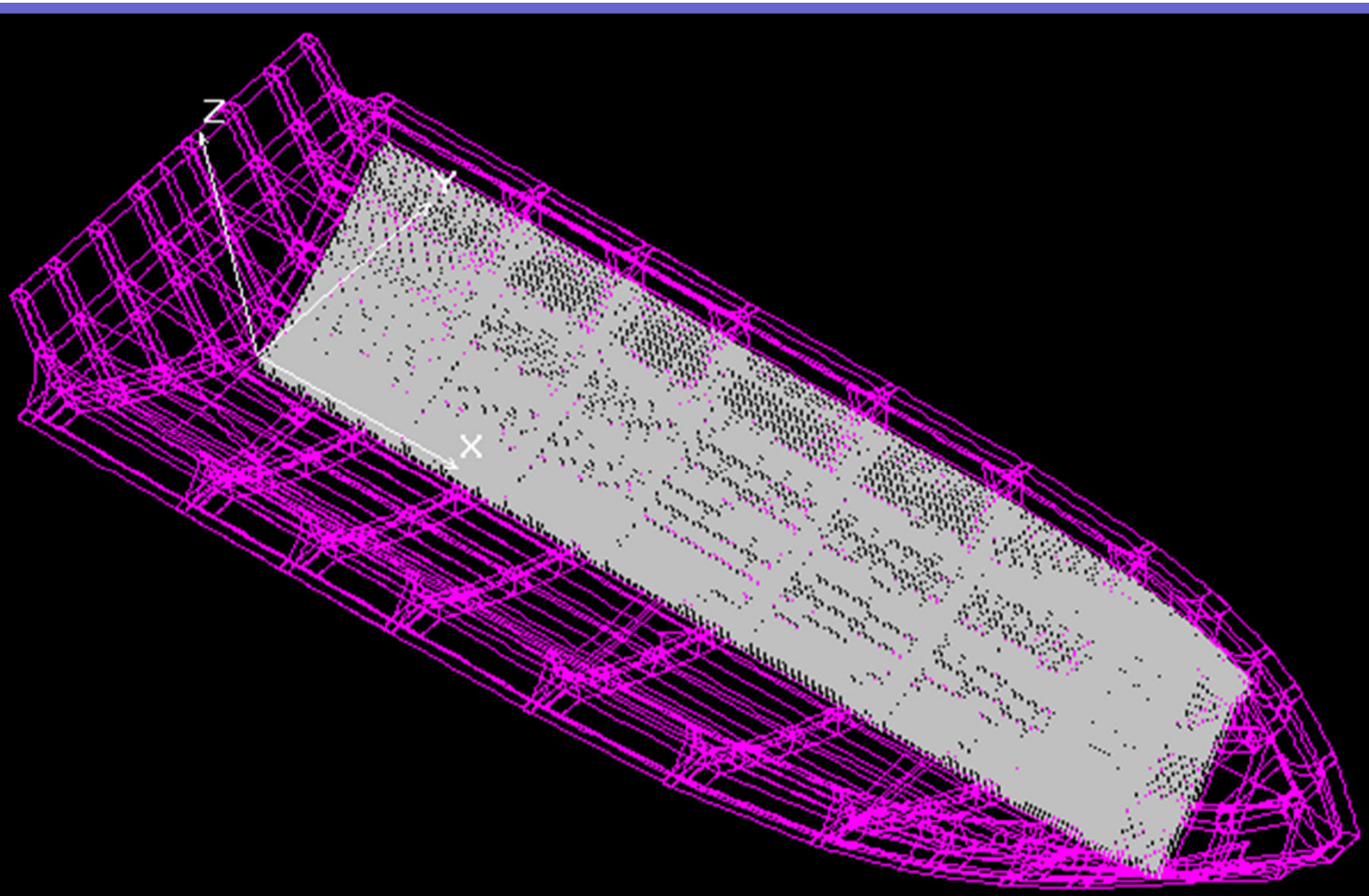
850B- FEA Analysis: Large Area Slam (LAS)



LC6-LAS- Loading

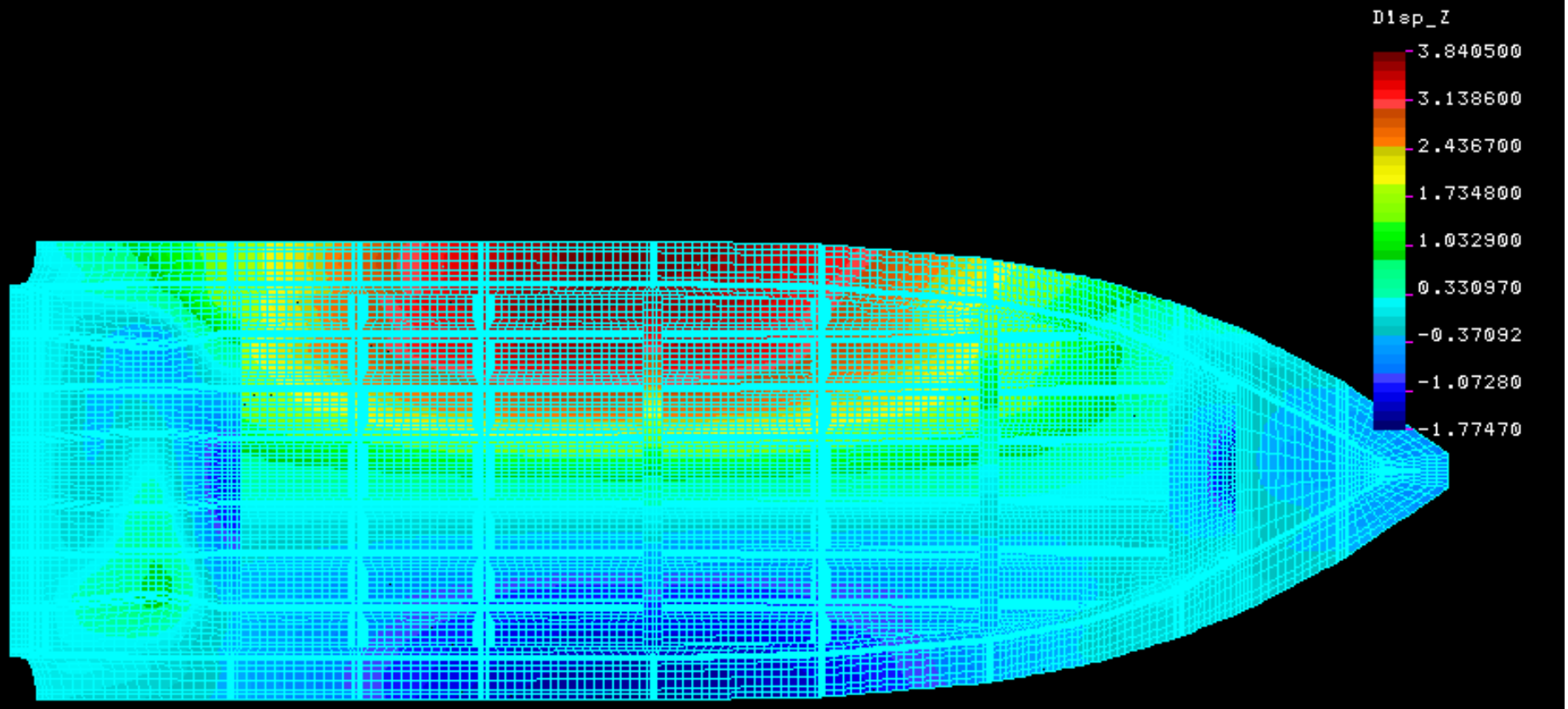
- Pressure load 5.57 psi
- Total load 52,400 lbs
- 13,100 lbs running weight at 4 g's

LC6-LAS- 5.57psi Pressure Load



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LC6-LAS- Z Displacement - Deck



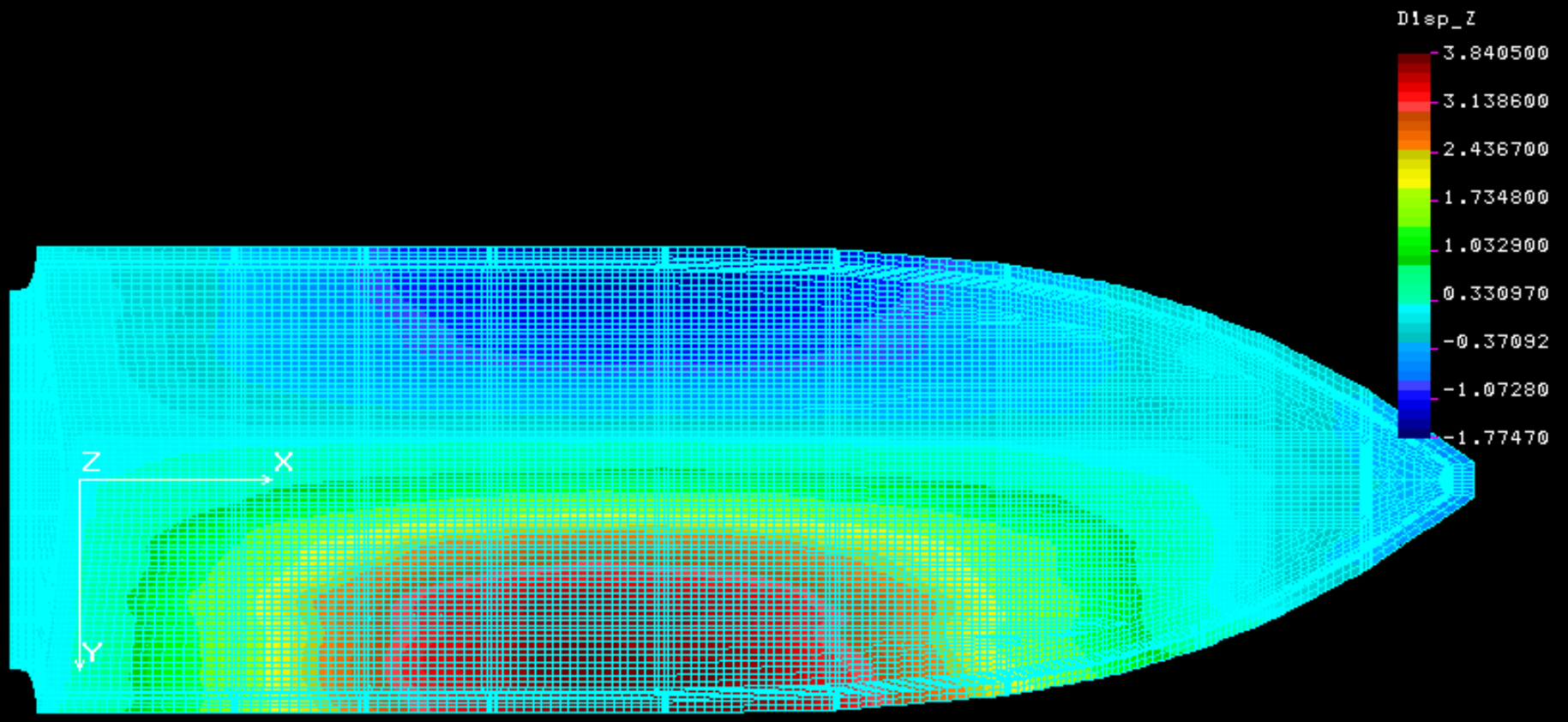
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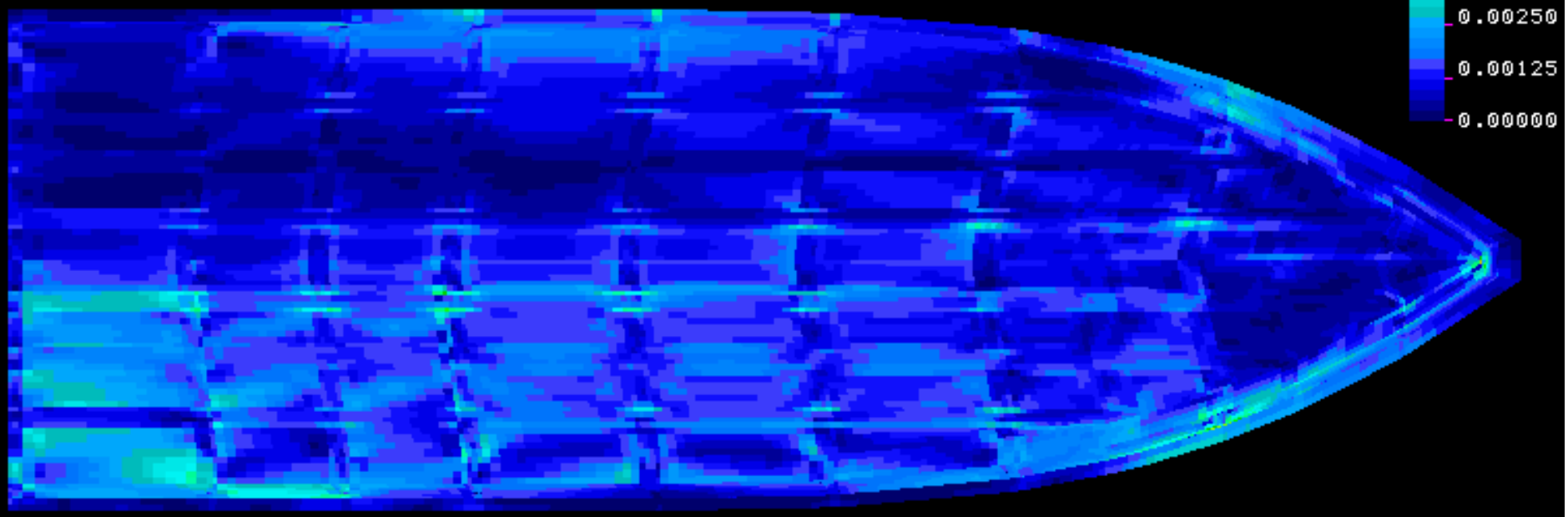
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LC6-LAS- Z Displacement - Hull



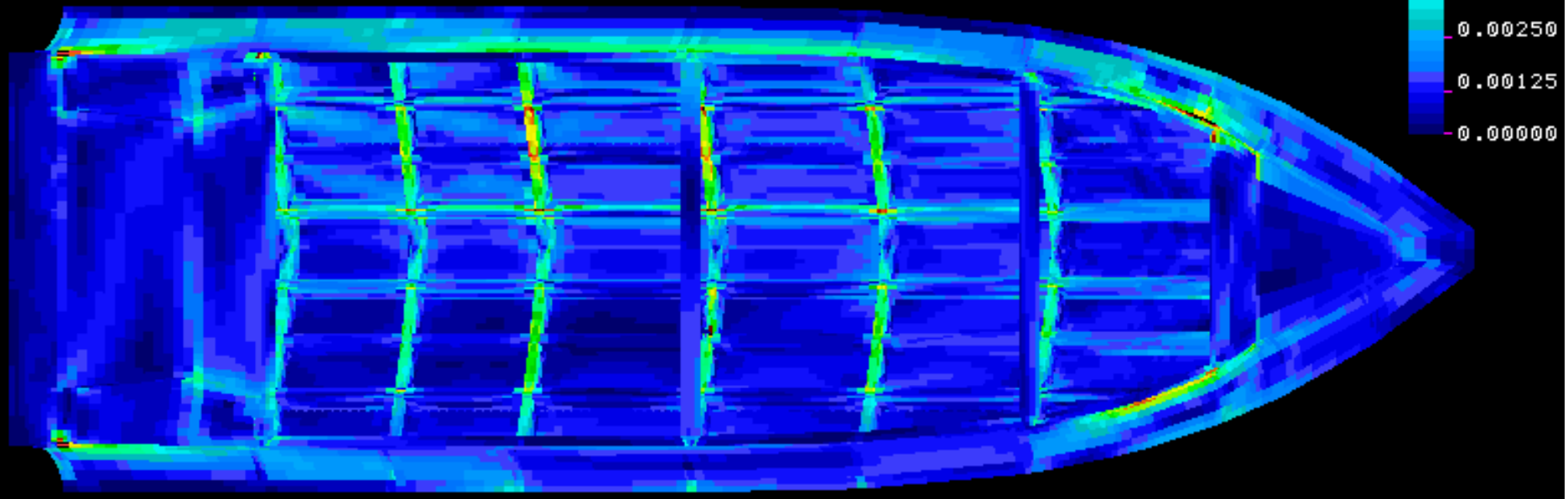
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LC6-LAS- Hull Shell Strain



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LC6-LAS- Deck Strain



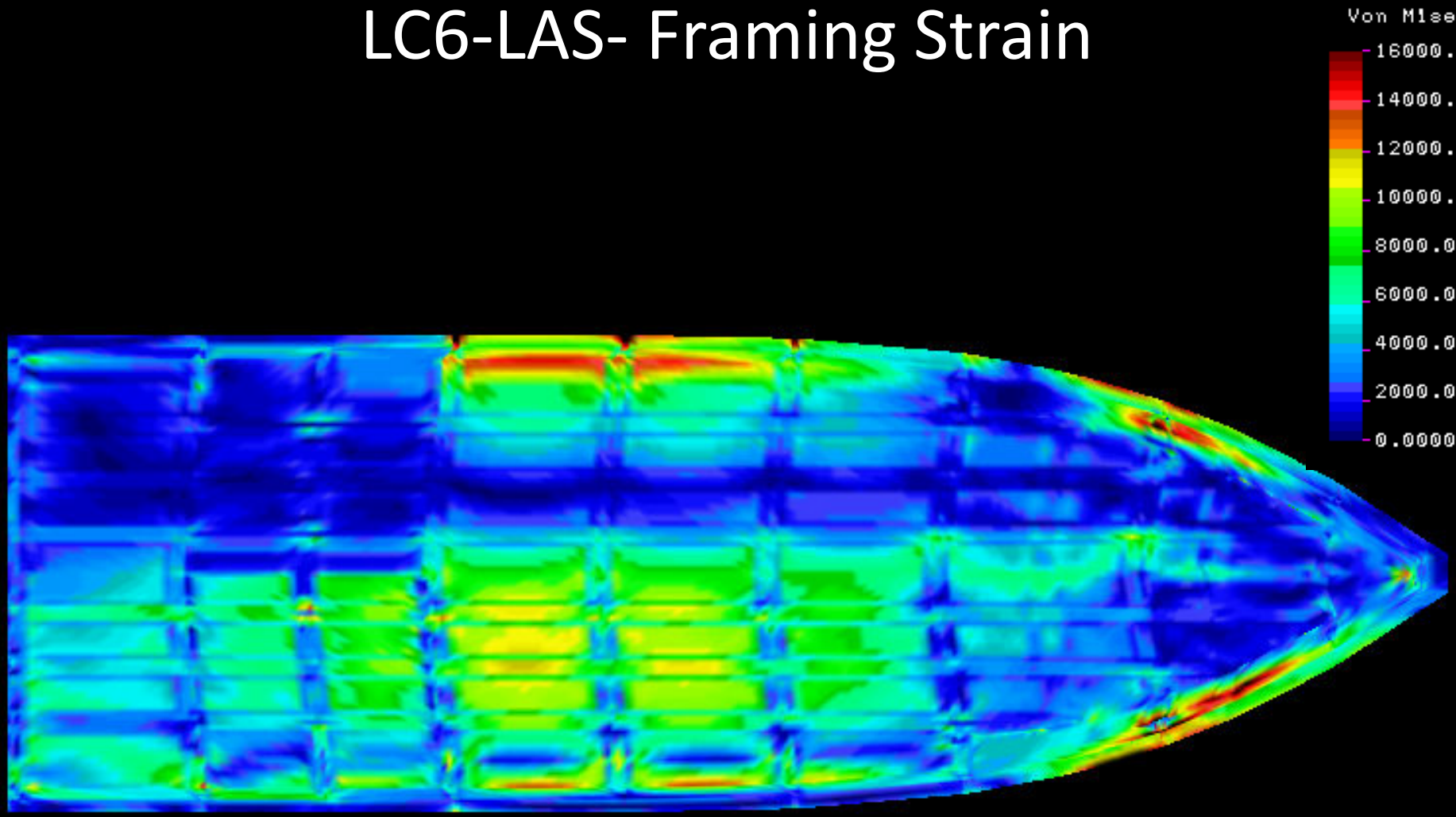
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LC6-LAS- Framing Strain



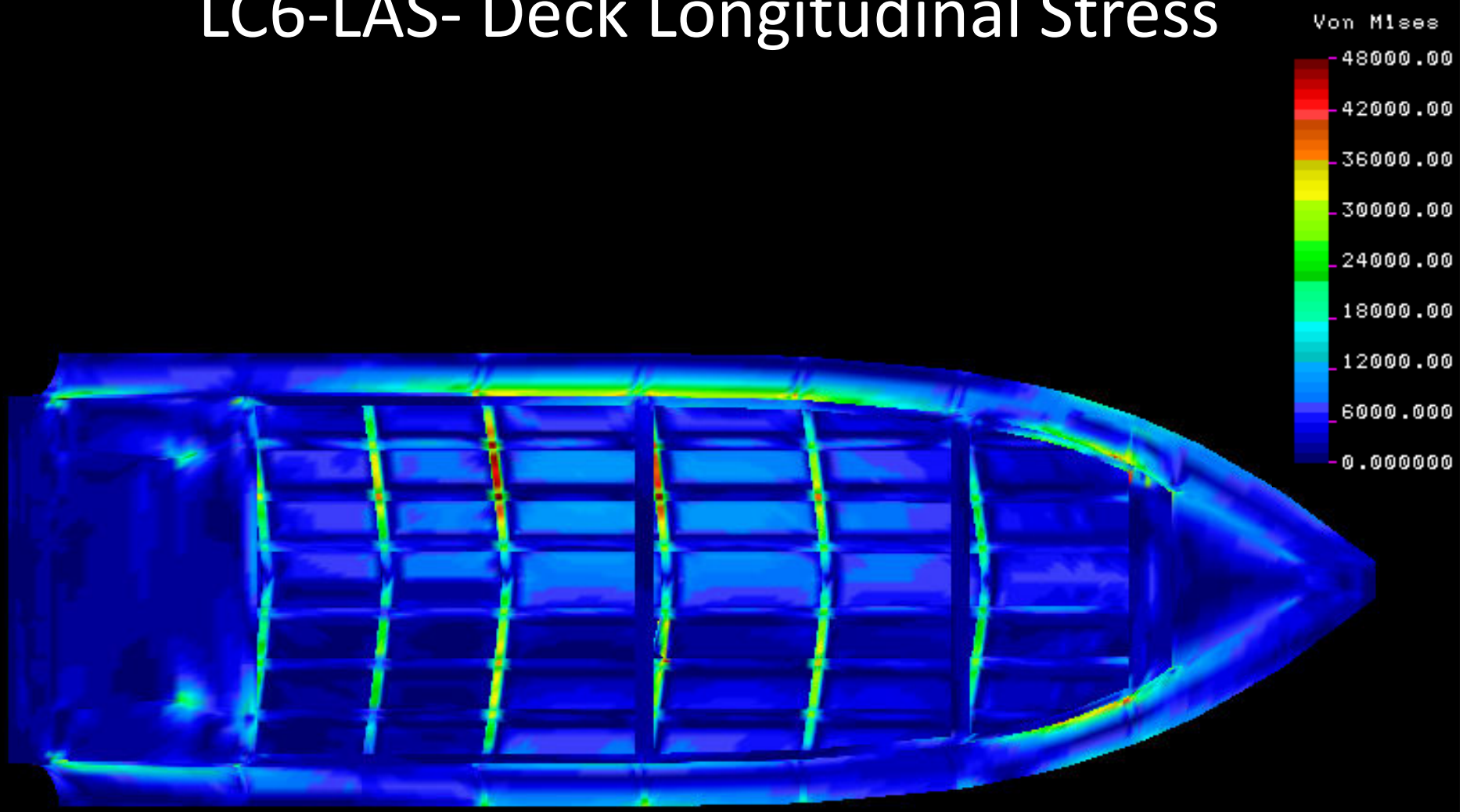
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LC6-LAS- Deck Longitudinal Stress



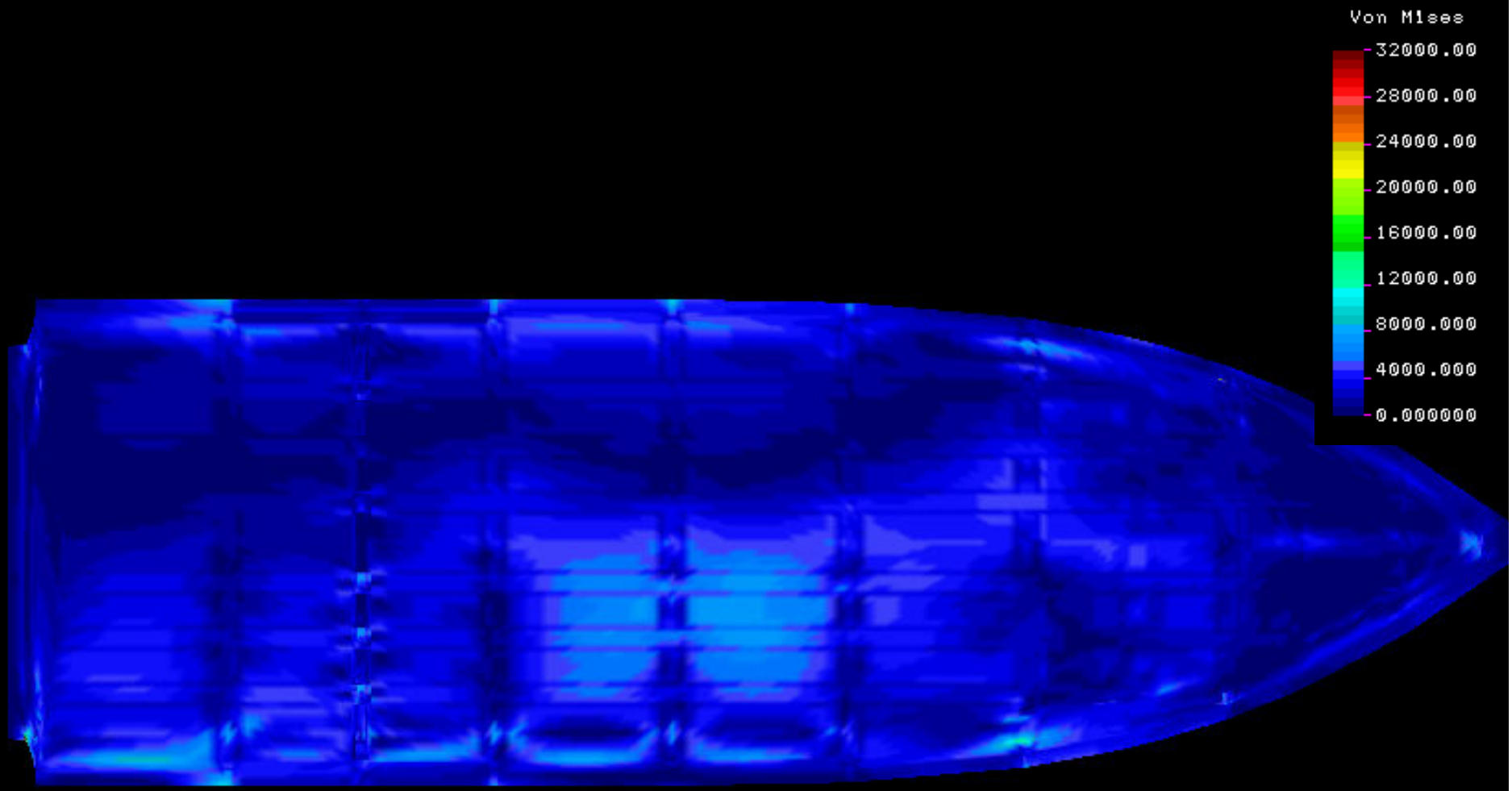
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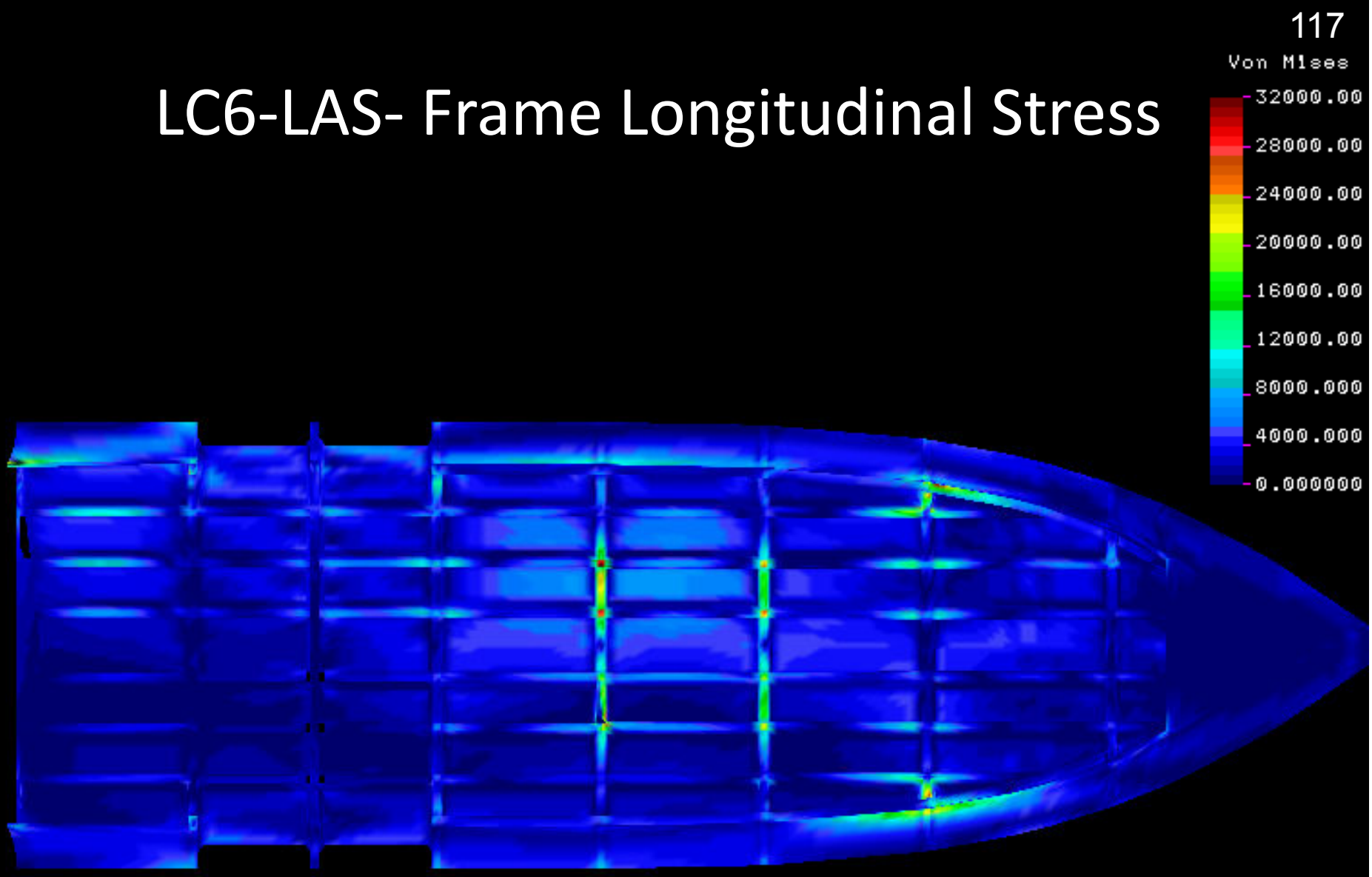
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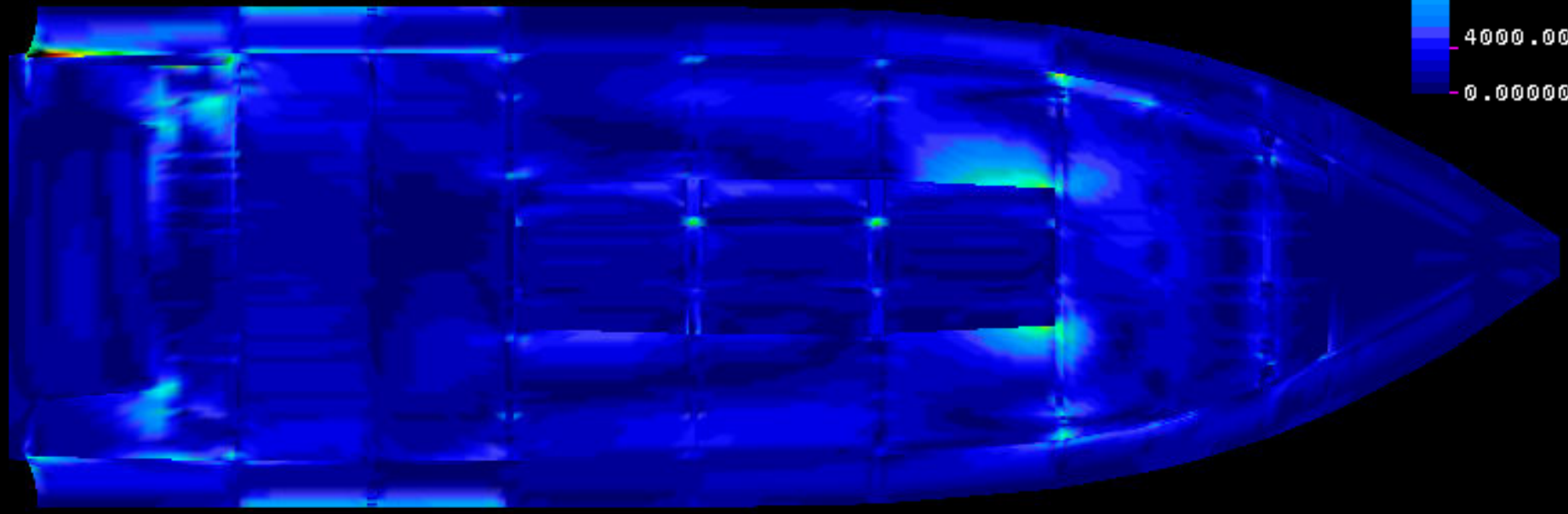
LC6-LAS- Hull Shell Longitudinal Stress



LC6-LAS- Frame Longitudinal Stress



LC6-LAS- Deck Transverse Stress



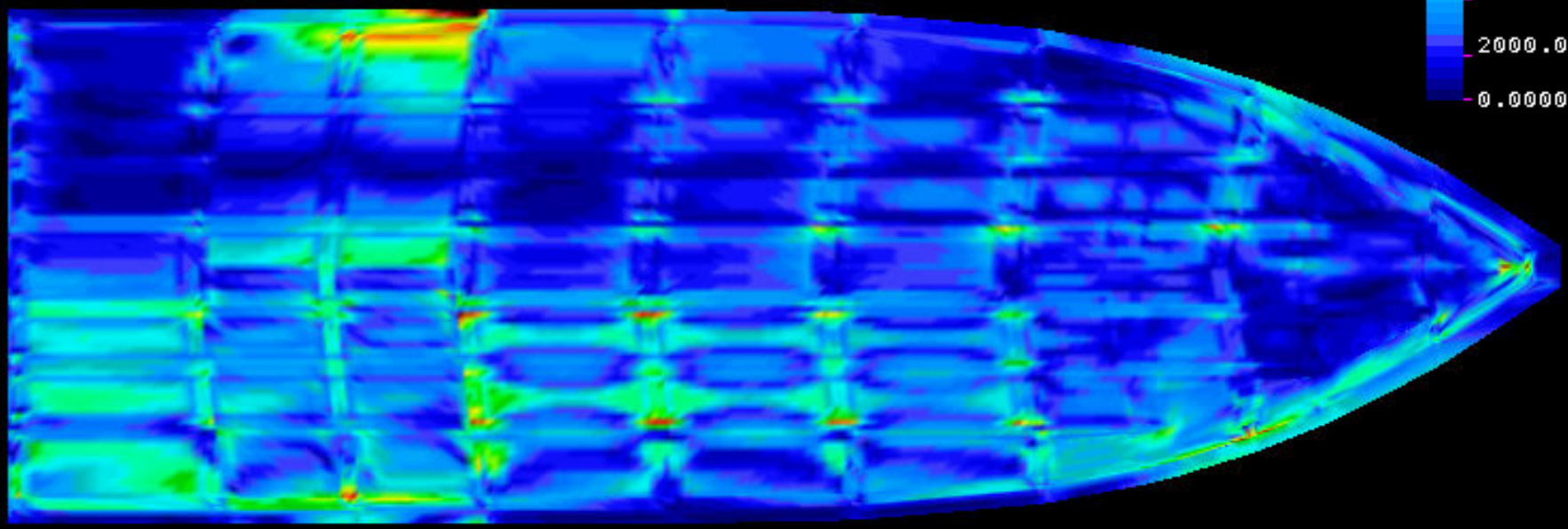
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LC6-LAS- Hull Transverse Stress



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850B- LAS Summary

- Hull range of deflection 3.84 to -1.77 in.
- Local panel deflection 0.25 in.
- Maximum strain 0.008 in/in
- Maximum framing stress 45,000 psi
- Maximum hull shell stress 15,000 psi

850B- FEA Analysis: Calm Water Planning (C.W.P.)

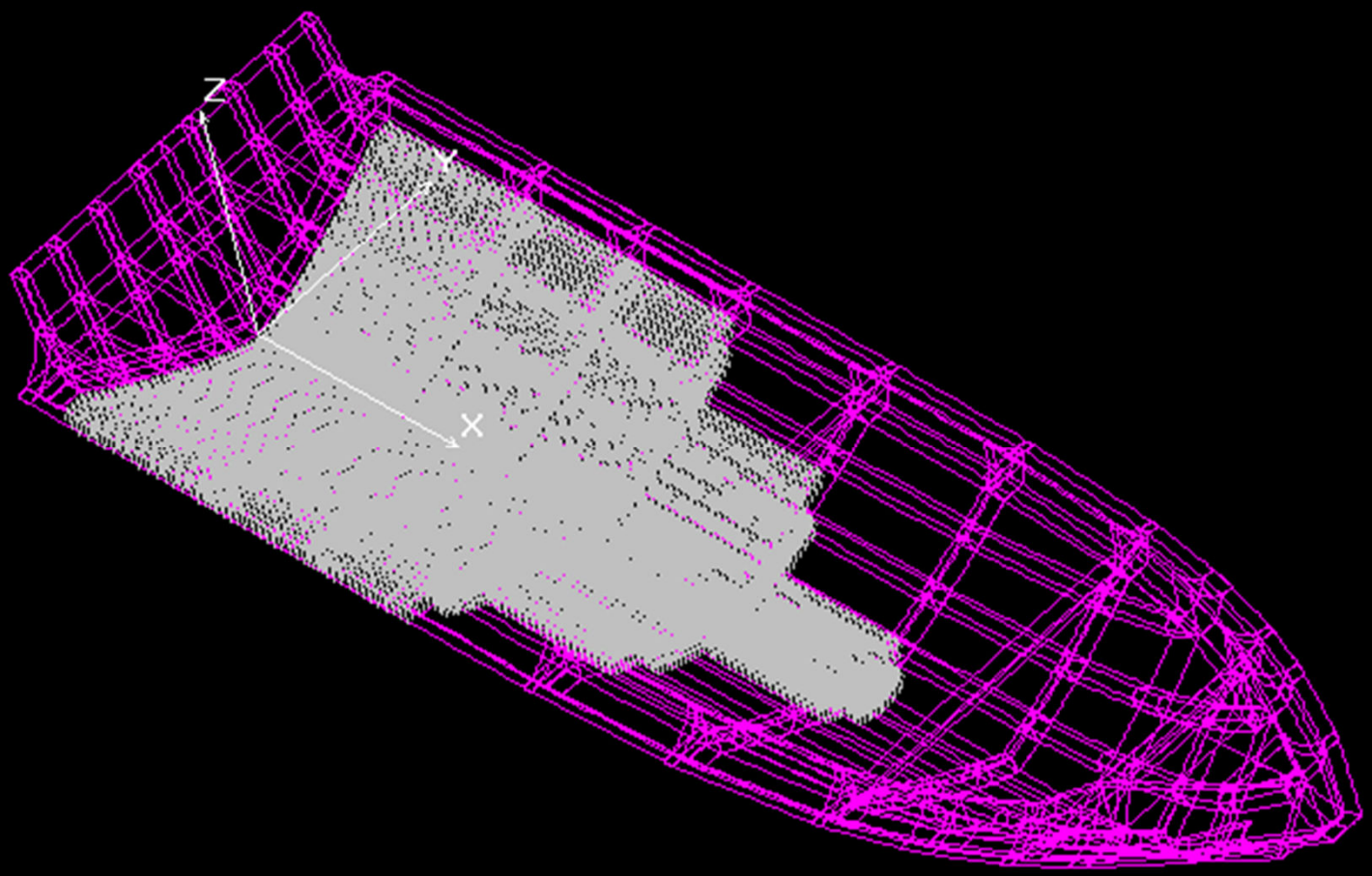


LC7-CWP- Load

- Boat weight 13,100 lbs
- Bottom pressure 1.23 psi (13,100 lbs total)

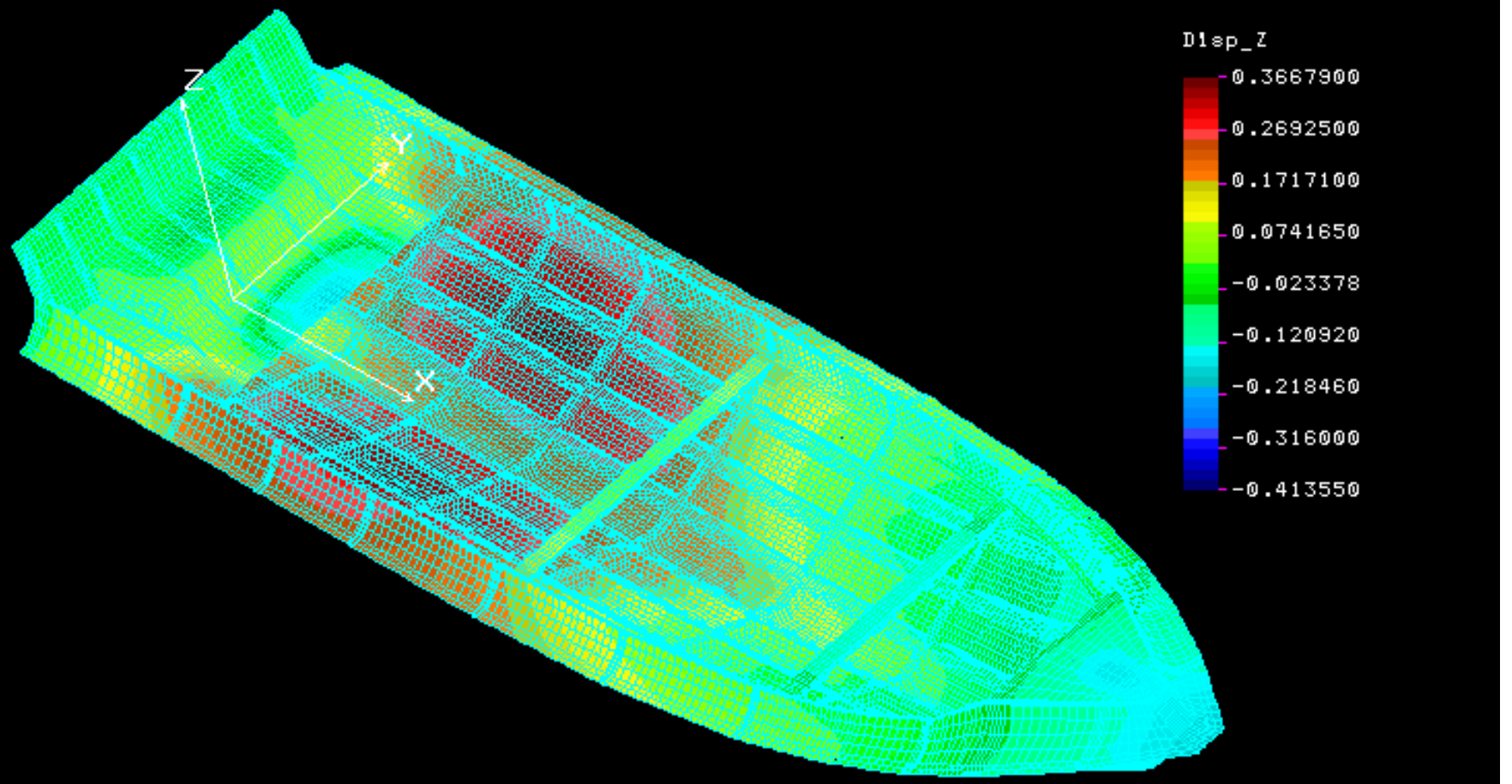
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LC7-CWP- 1.1psi Pressure Load



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LC7-CWP- Deck Deflection



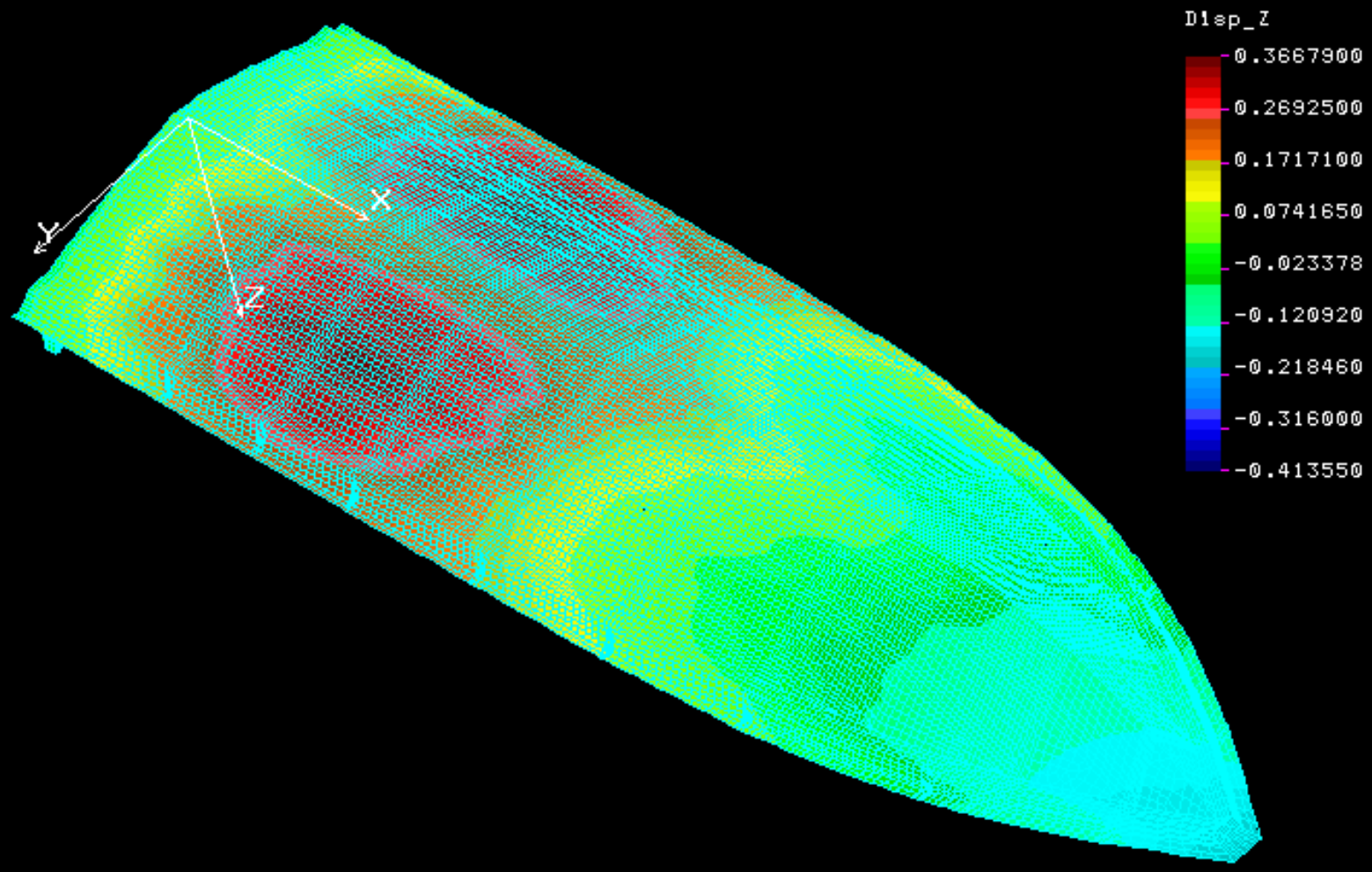
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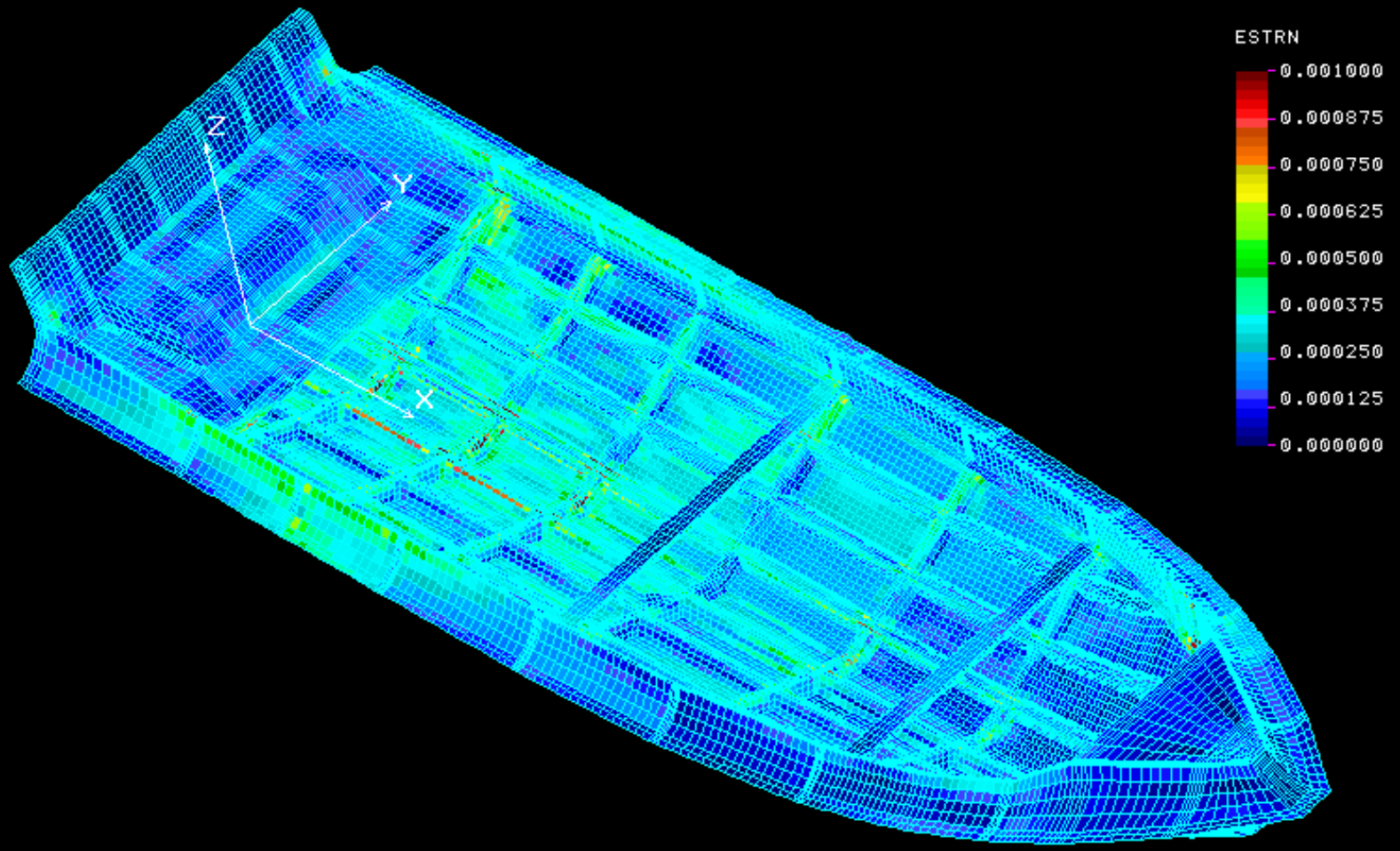
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LC7-CWP- Hull Deflection



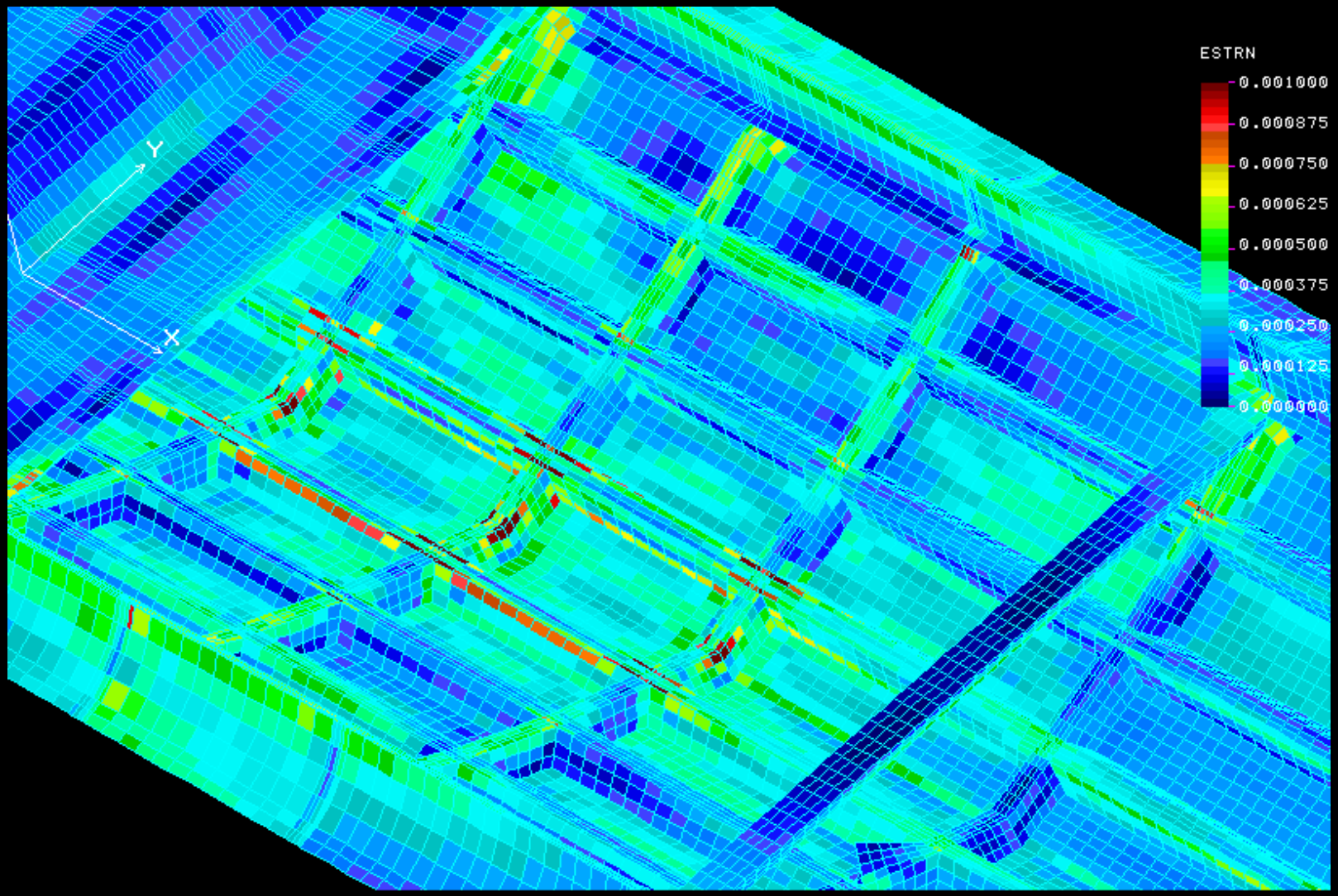
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LC7-CWP- Strain



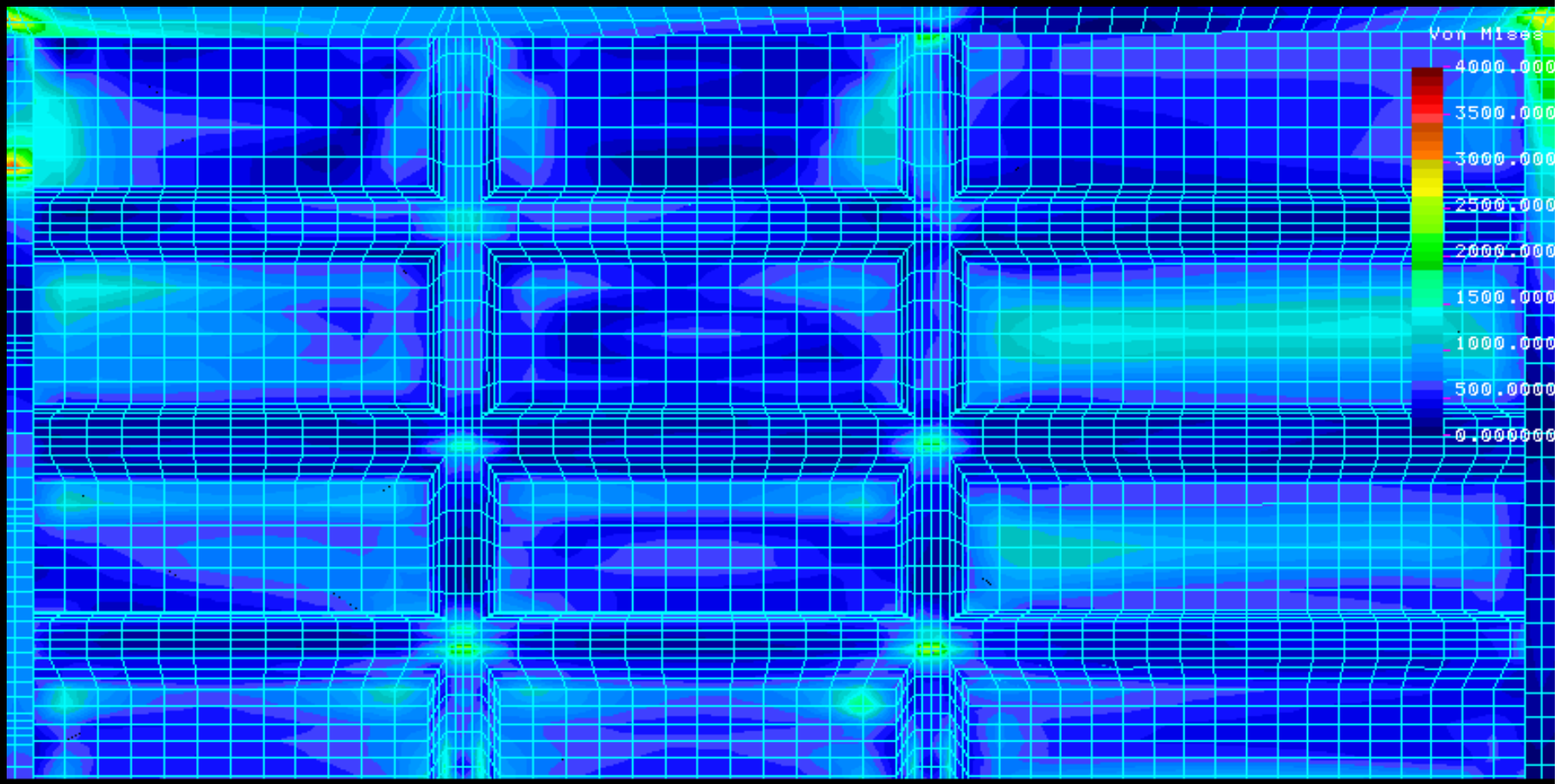
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LC7-CWP- Strain



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LC7-CWP- Transverse Hull Stress



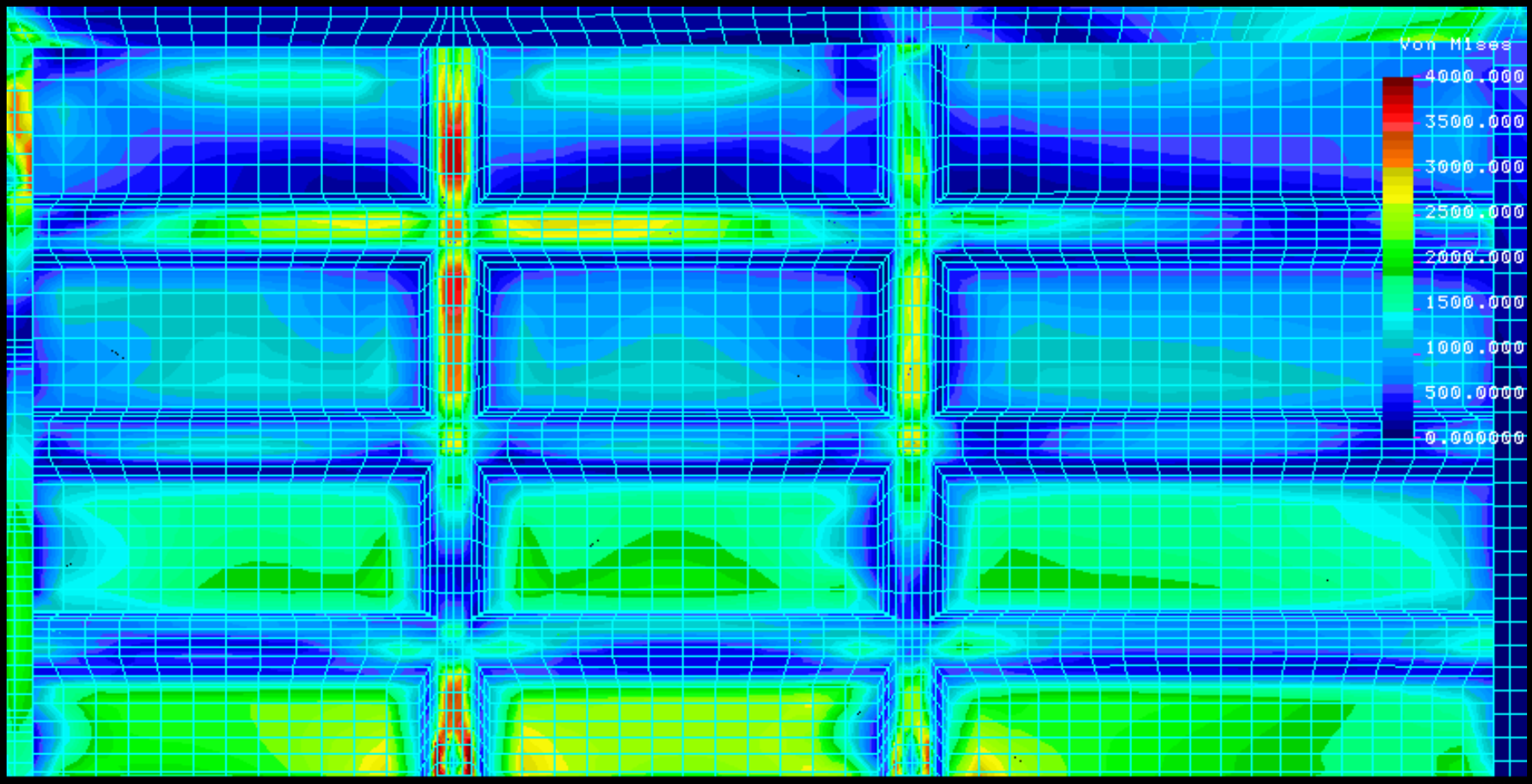
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LC7-CWP- Frame Cap and Longitudinal Hull Stress



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850A- CWP Summary

- Range of deflection 0.78 in.
- Local panel deflection 0.03 in
- Maximum strain 0.001 in/in
- Maximum longitudinal cap stress 2800 psi
- Maximum transverse cap stress 4000 psi
- Maximum transverse stress 1400 psi

850B- FEA Analysis: Boat Lifting Points (B.L.P.)

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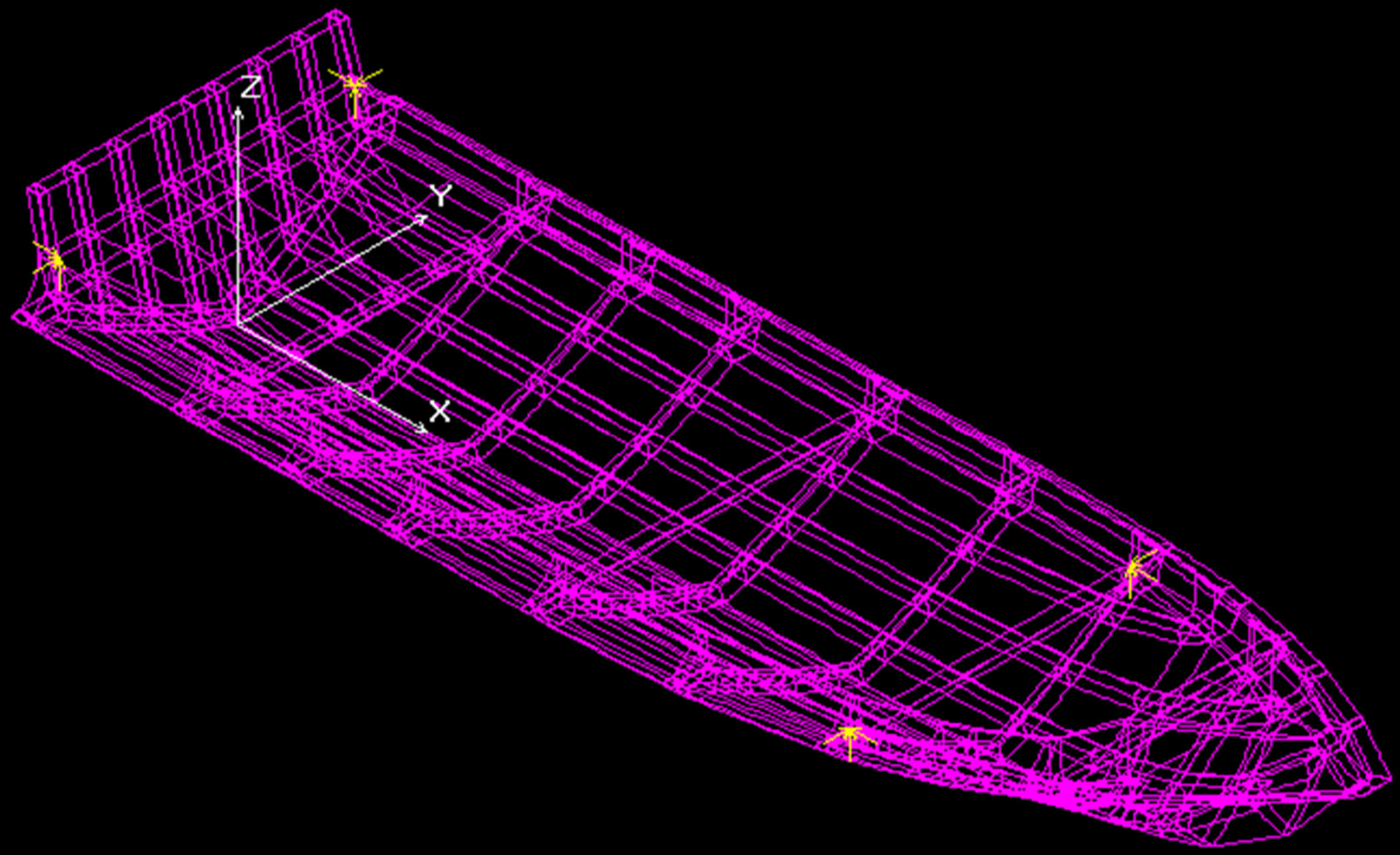
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
  - Redesigned to accommodate tube mounting.
  - Positioned for design LCG

LC8- BLP- Load Data

- Lift weight 5600, SF 6 (33,600)
- 4 point lift
- F_z all four lift points +8,400 lbs
- F_x at aft two lift points +13,527 lbs
- F_x at fwd two lift points -13,527 lbs
- F_y at stbd two lift points +5,381 lbs
- F_y at port two lift points -5,381 lbs

LC8- BLP- Force Vector at Lift Points



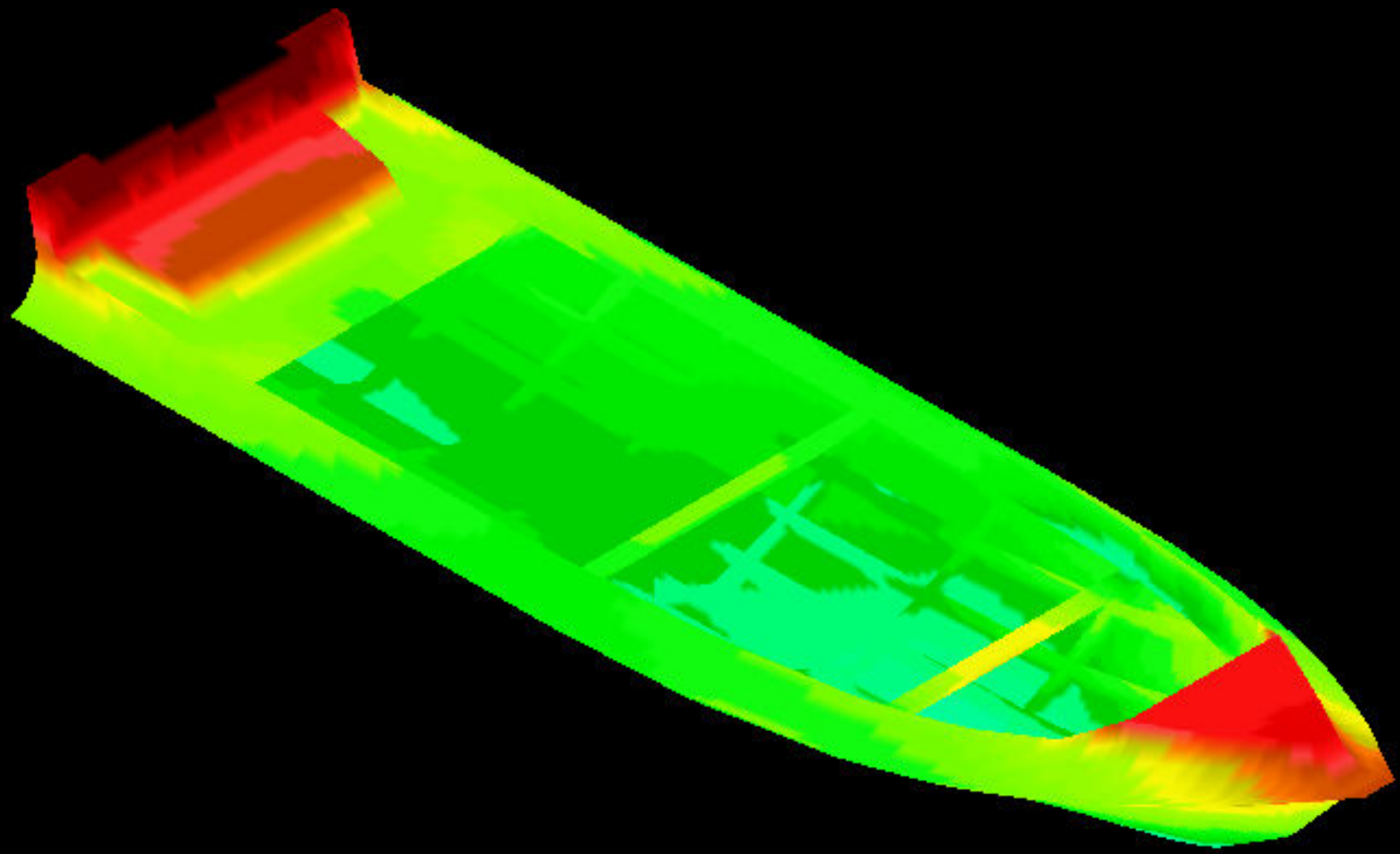
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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints $F_r < 1$ lb
- Thus constraints do not affect results

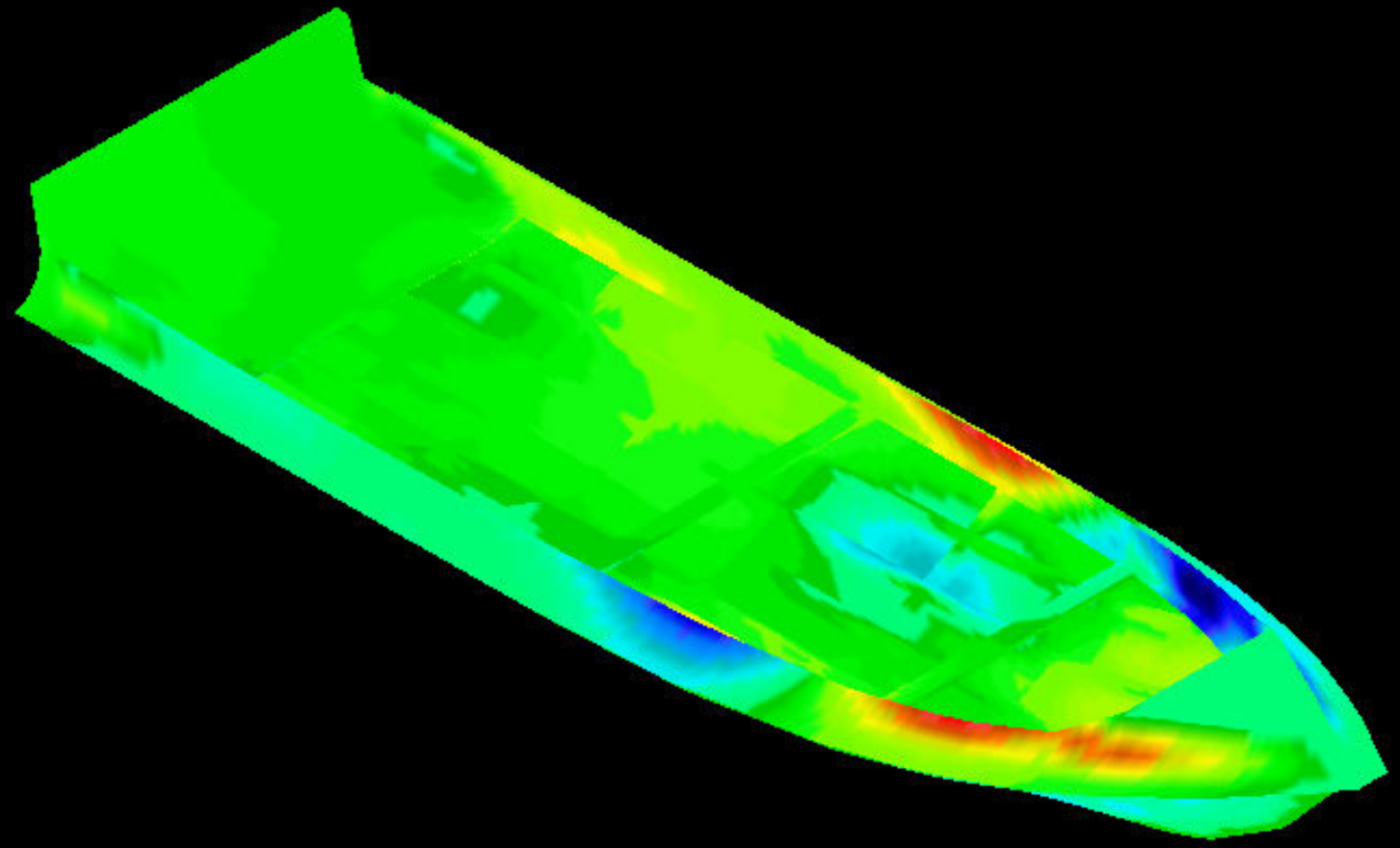
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LC8- BLP- X Displacement



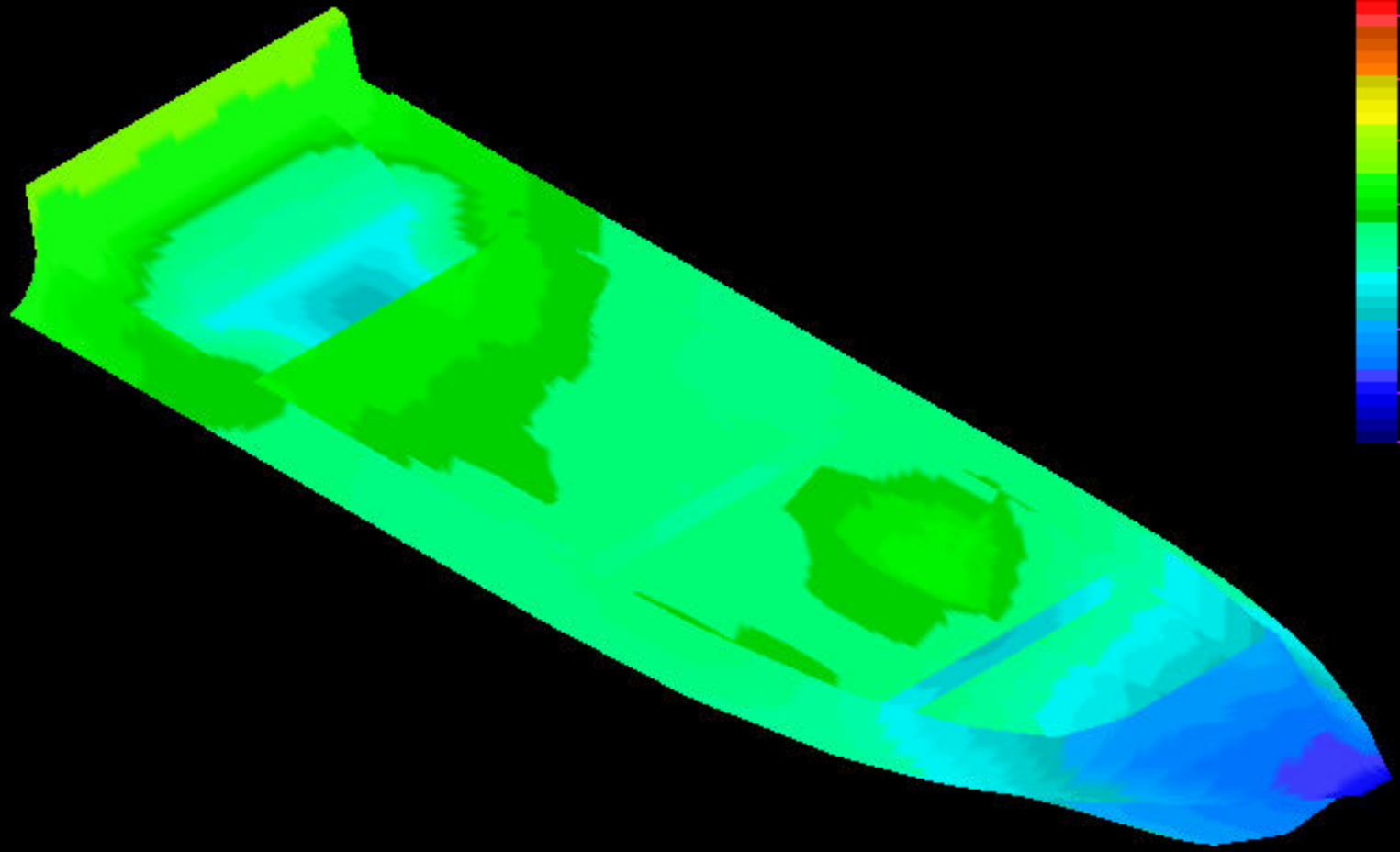
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LC8- BLP- Y Displacement



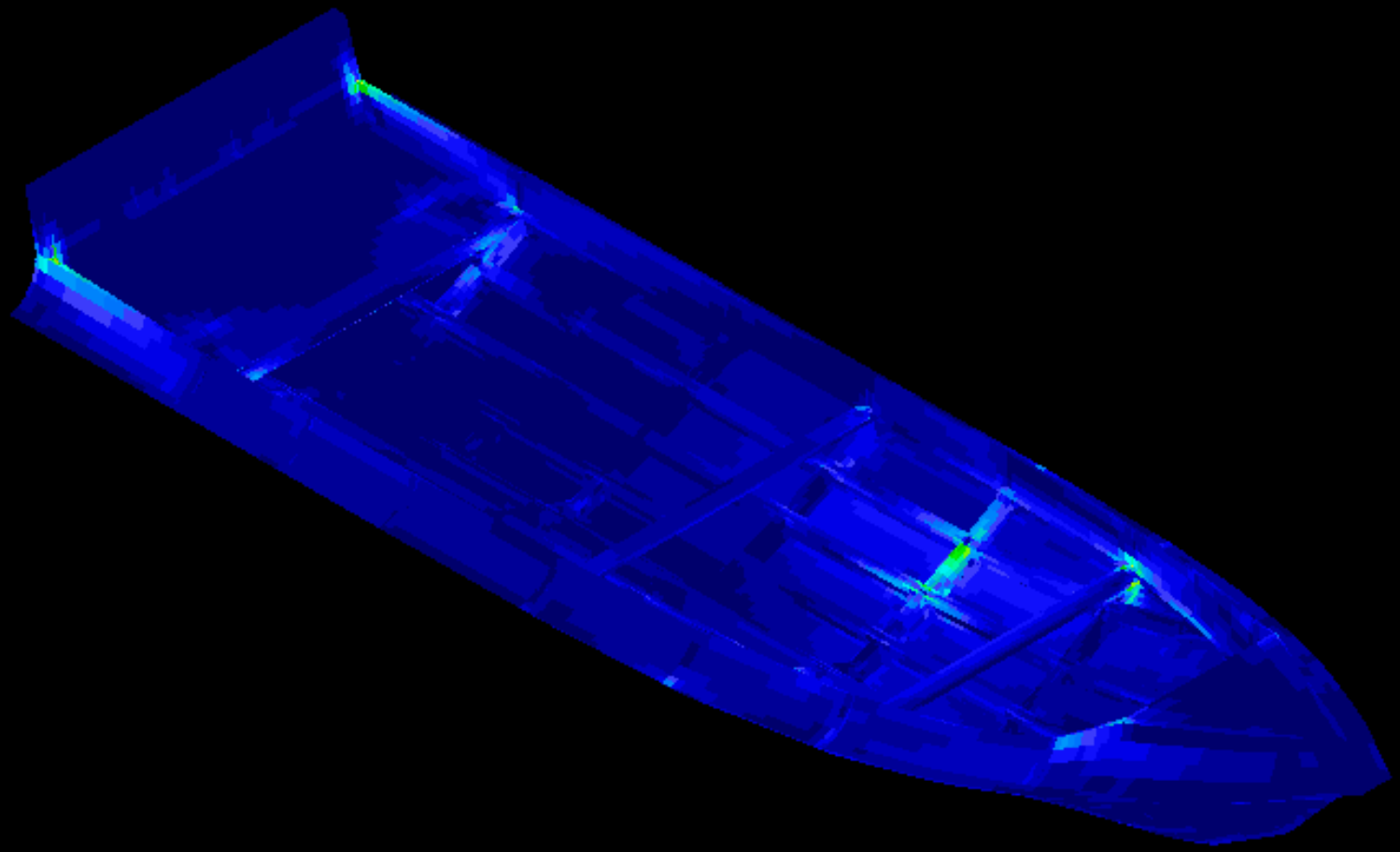
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LC8- BLP- Z Displacement



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LC8- BLP- Strain



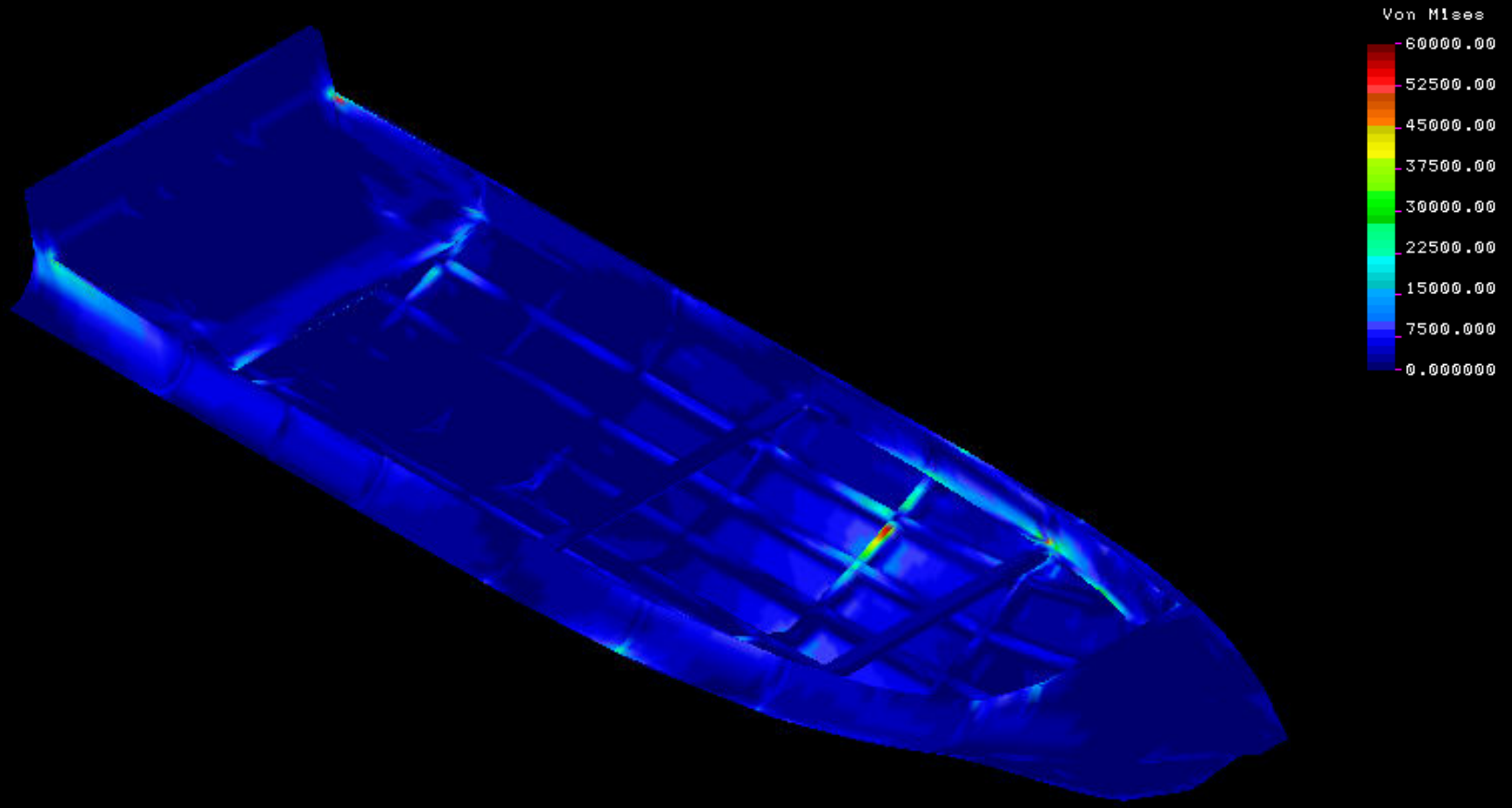
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LC8- BLP- Longitudinal Stress Fwd Lift Point



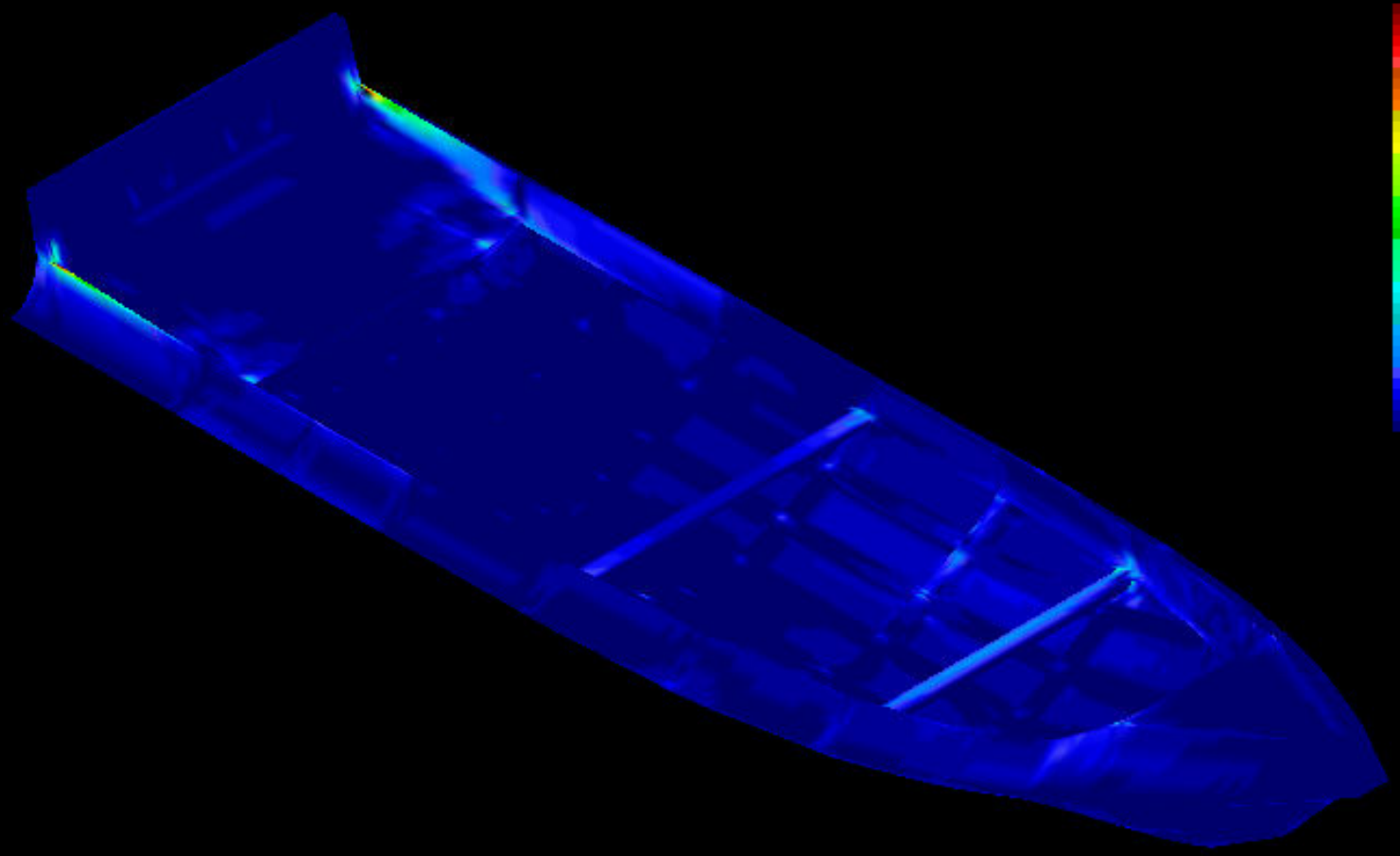
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LC8- BLP- Transverse Stress



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LC8- BLP- Lift Analysis Summary ***

- Hull range of deflection 1.2 to -2 in.
- Maximum strain 0.016 in/in
- Maximum framing stress 60,000 psi
- Maximum hull shell stress 8,500 psi

850B- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

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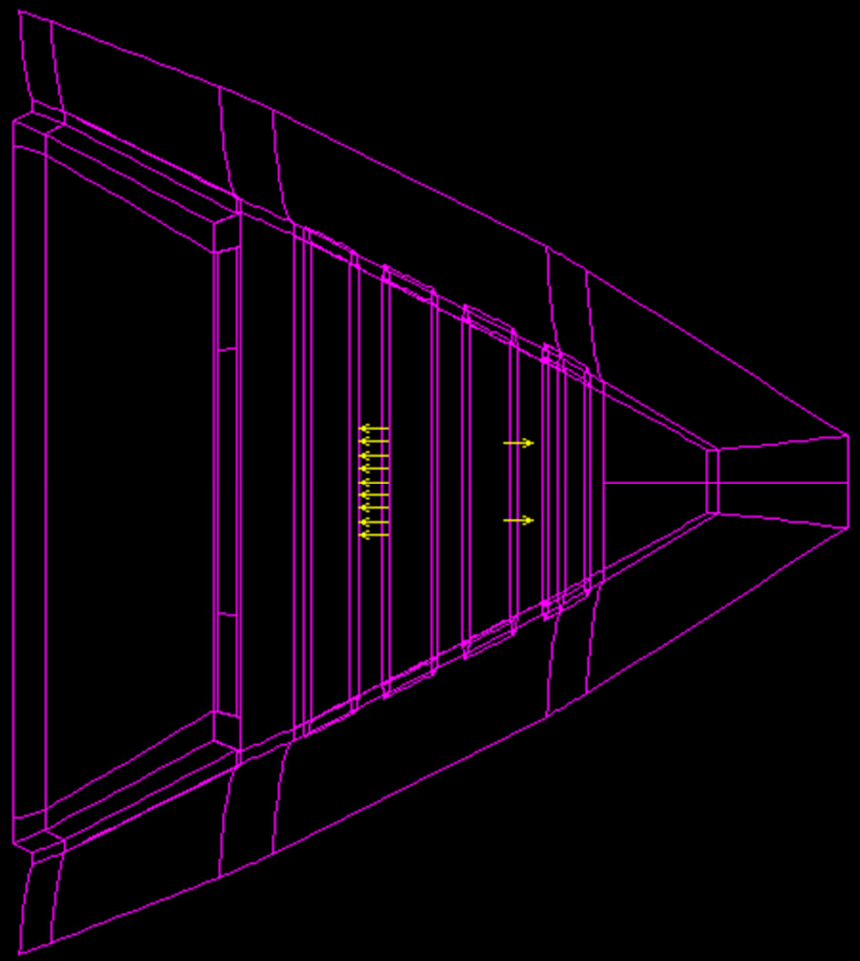
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Gun Mount Framing Notes

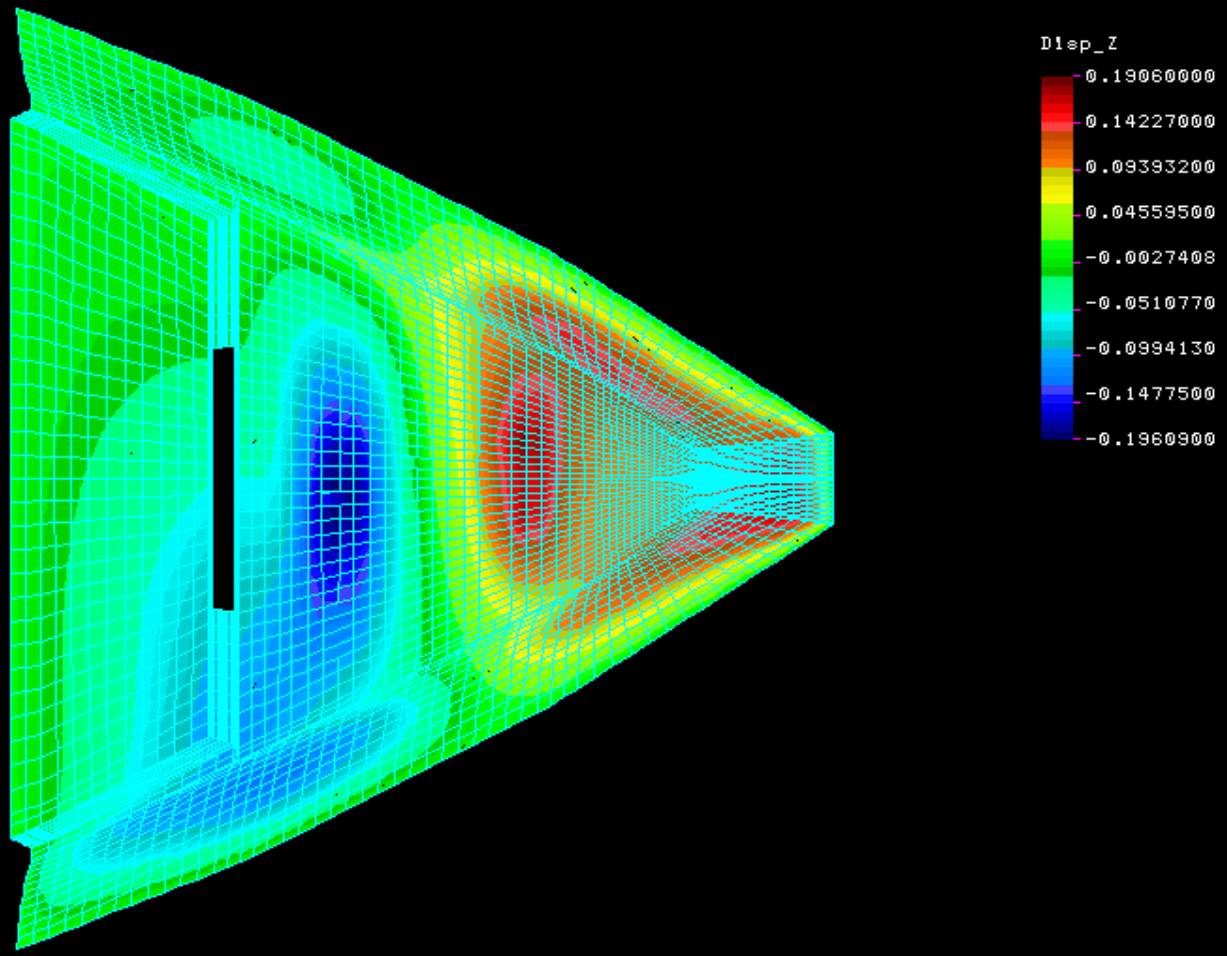
- Four transverse frames, TR3030X, are placed on five inch centers
- Skin laminate is 2oz, 2 x 2408,2 x 3610
- Frame laminate:
  - 24 oz (+/-45) on PRISMA Beam
  - 3 layers 1810 warp uni
  - 2408 (+/-45) cover fabric

LC9- GML- Long. Loading



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LC9- GML- Z Displacement



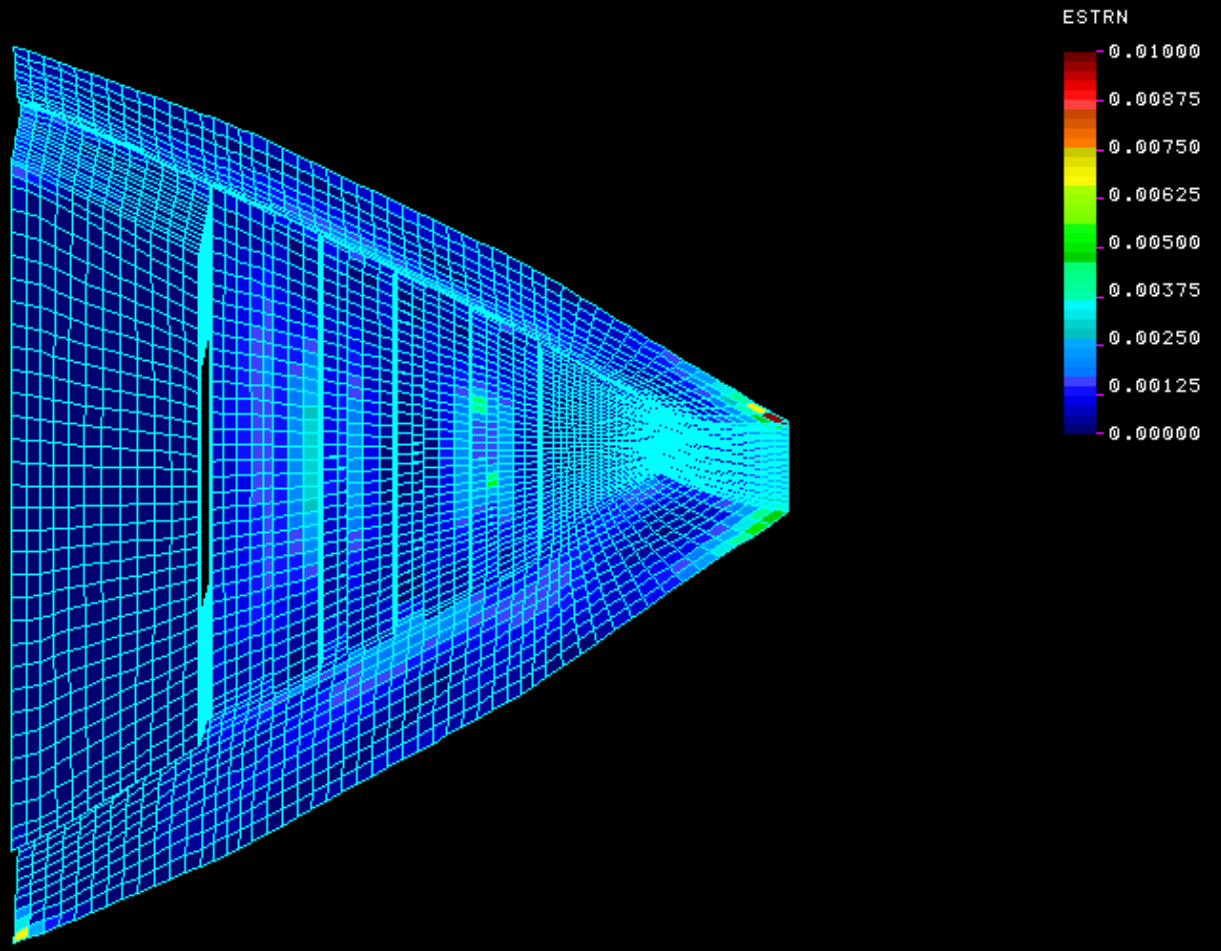
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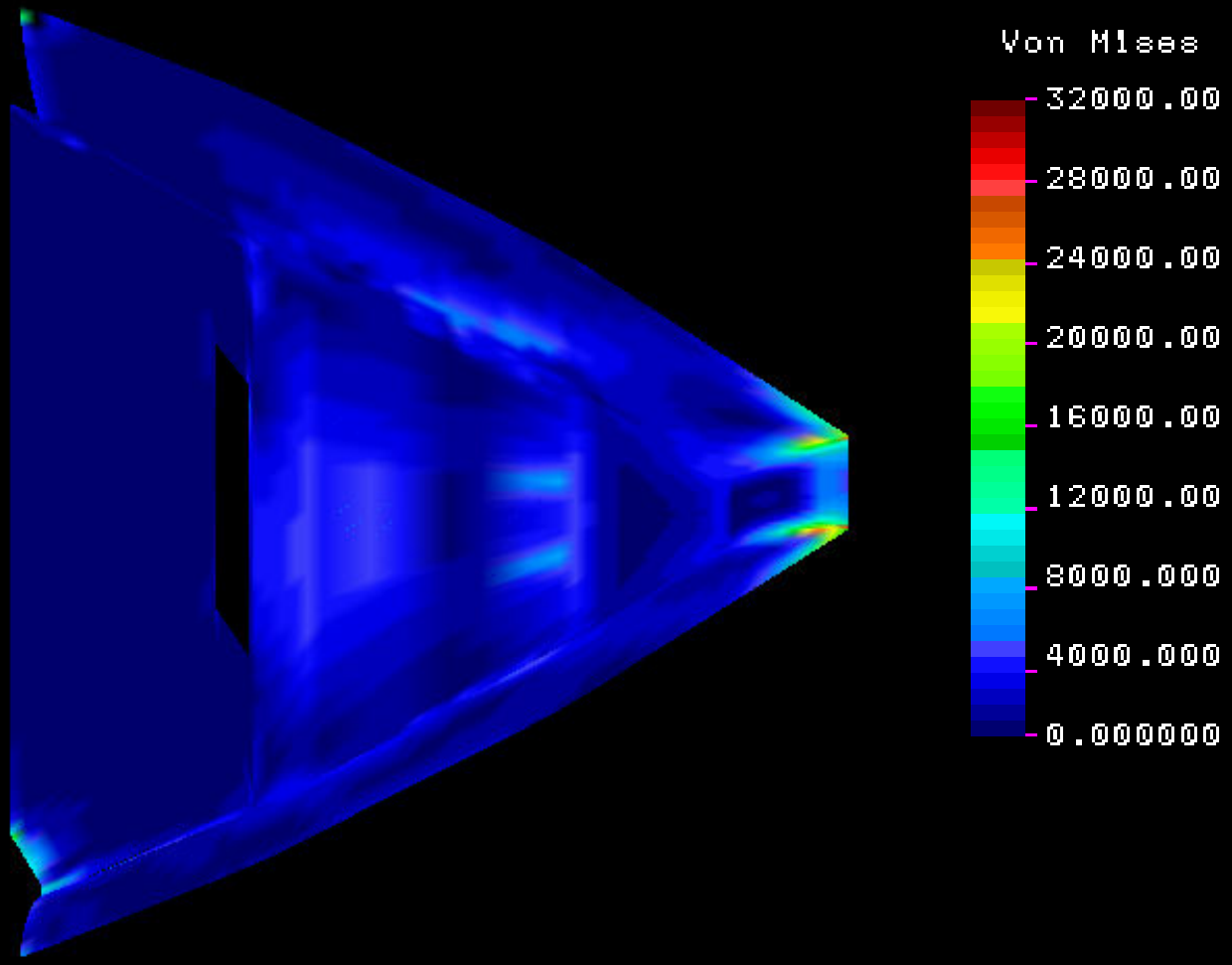
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LC9- GML- Strain (Bottom View)



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LC9- GML- Stress in Long. Ply (Top)



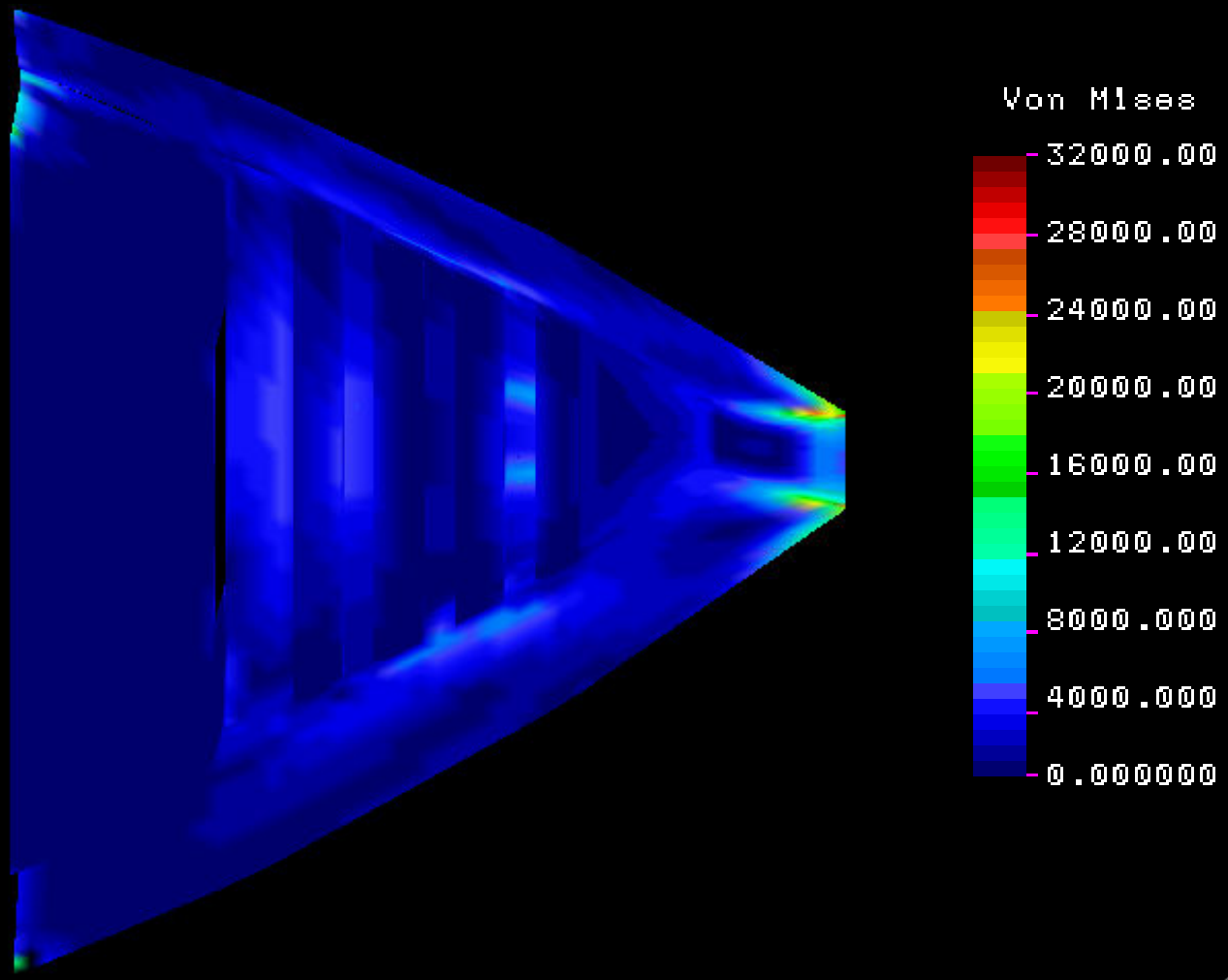
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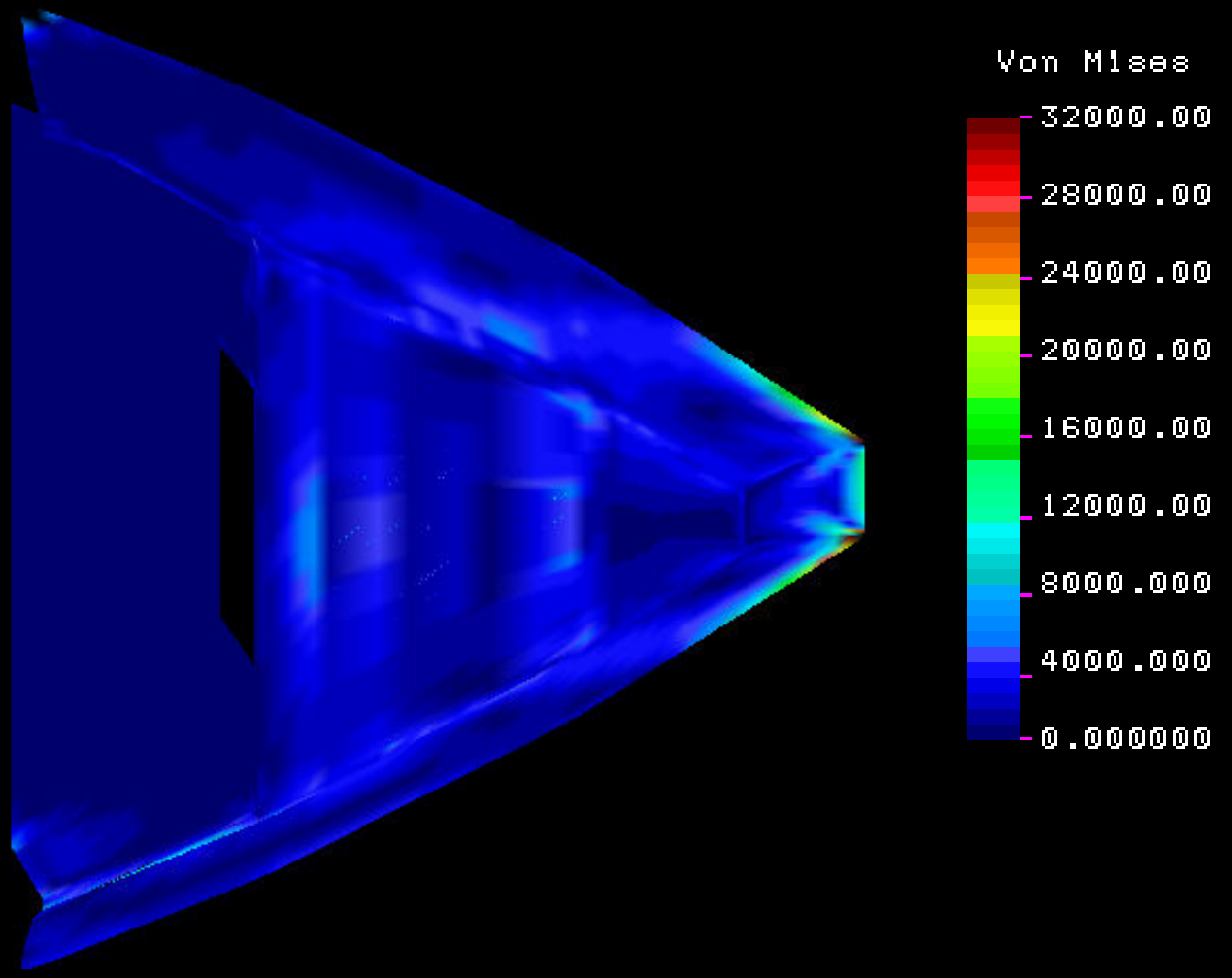
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LC9- GML- Stress in Long. Ply (Bottom)



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LC9- GML- Stress in Tran. Ply (Top)



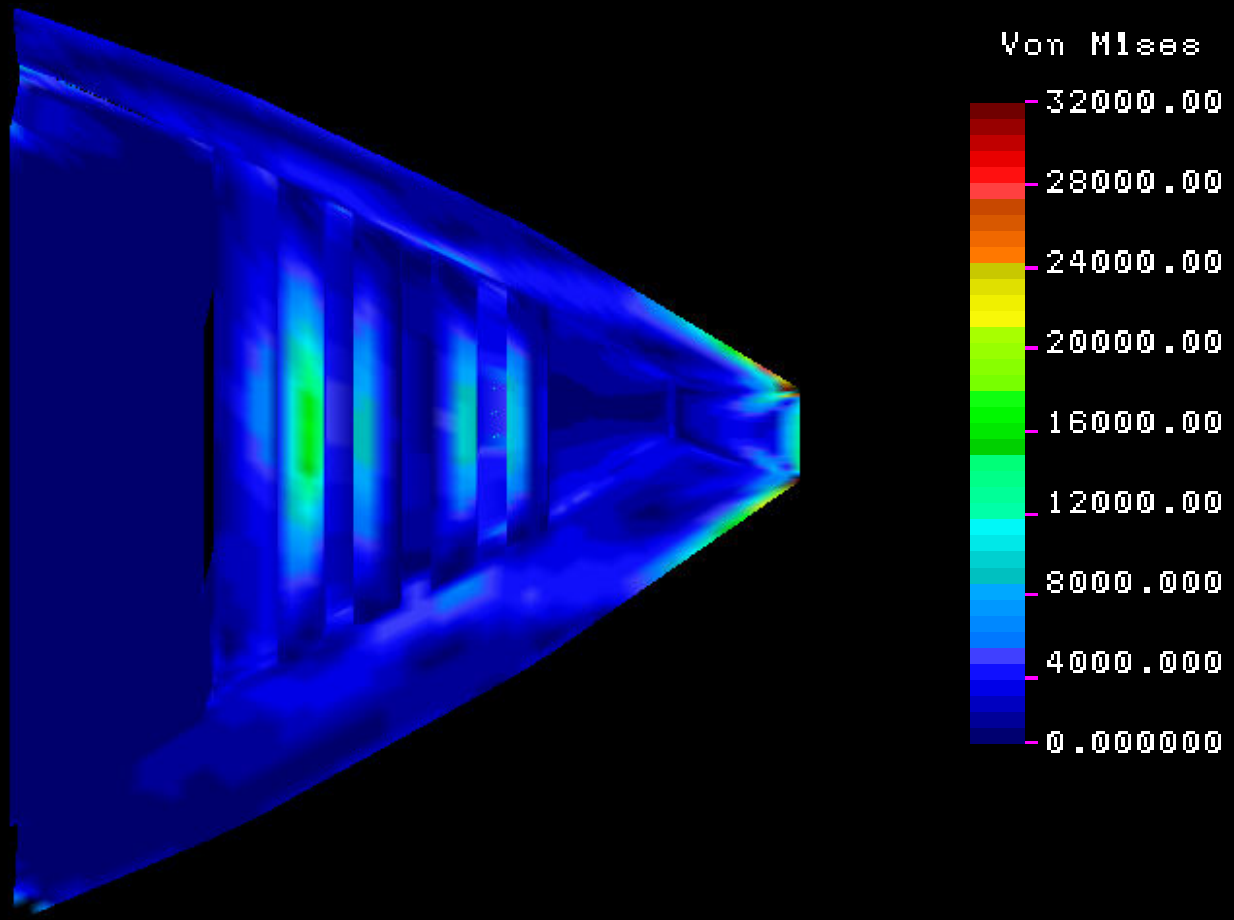
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LC9- GML- Stress in Tran. Ply (Bottom)



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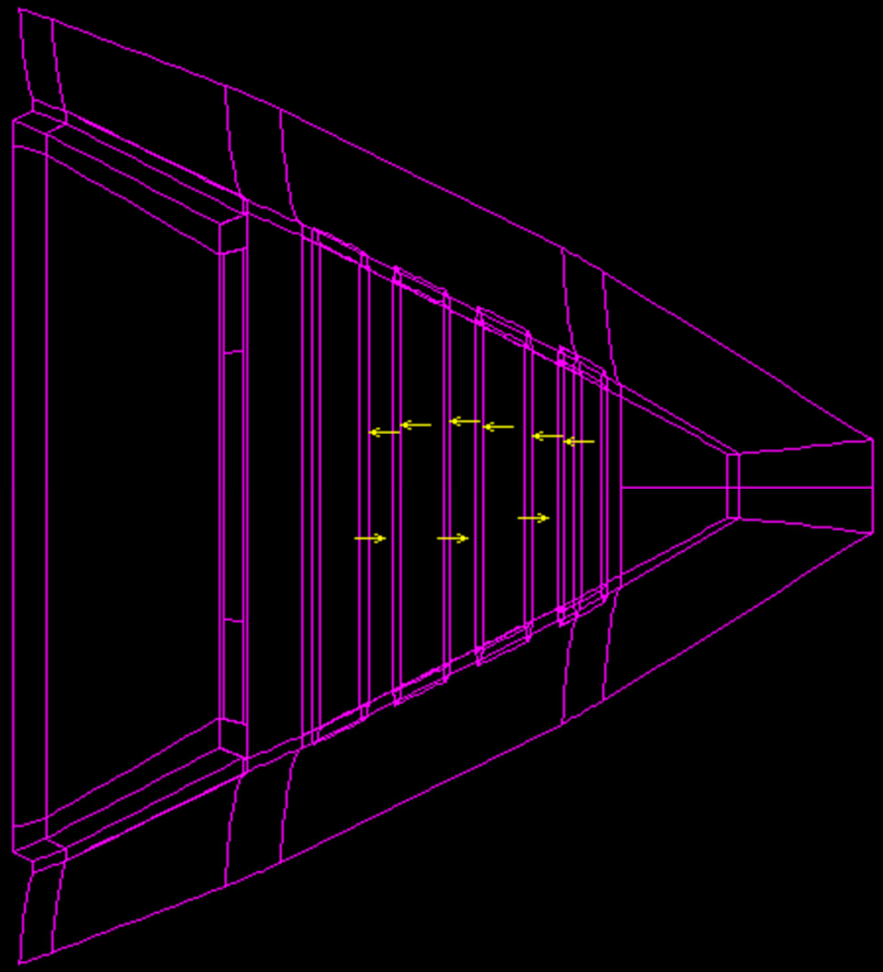
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850A- G.M.L- Summary

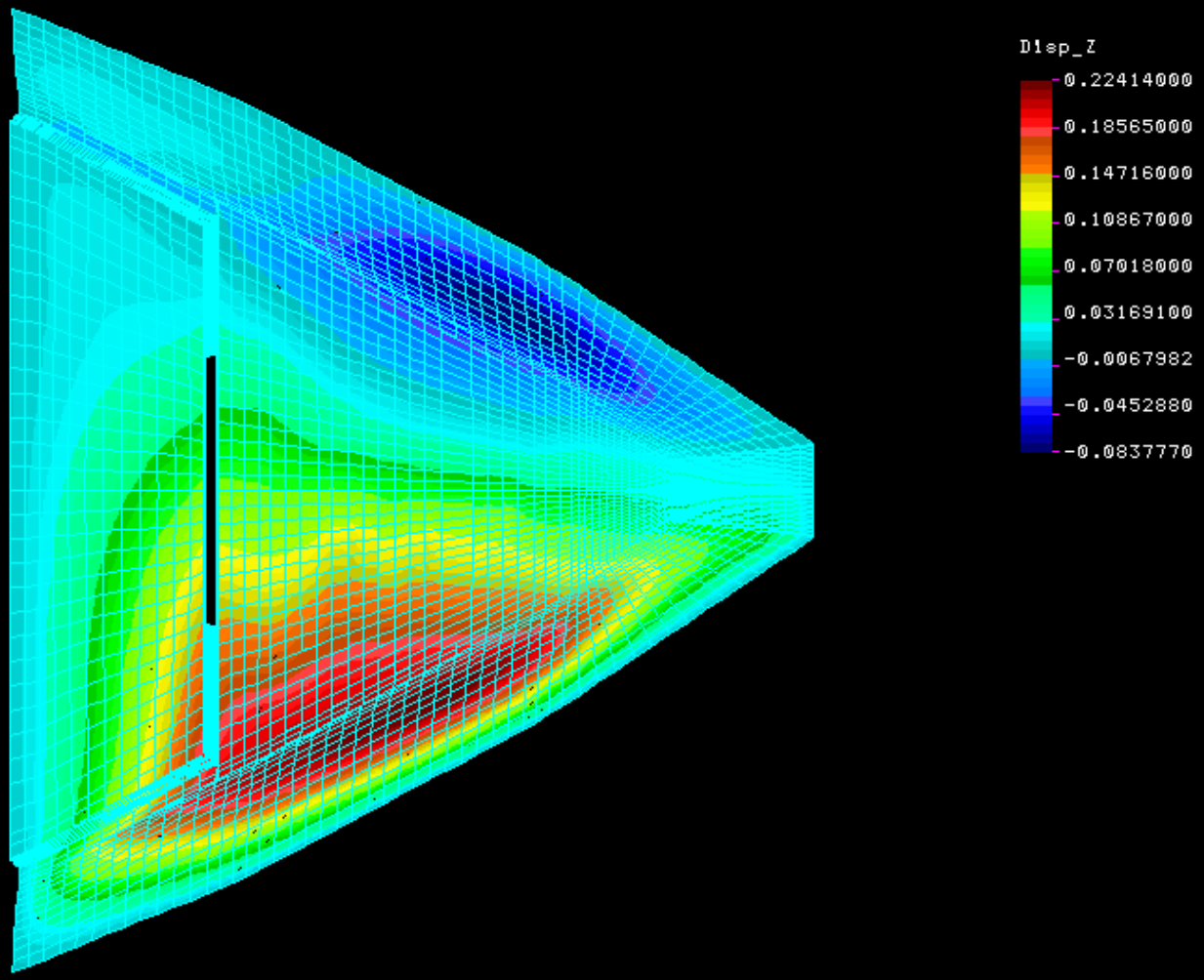
- Range of deflection 0.29 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 15,500 psi

LC10- GMT- Trans. Loading



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LC10- GMT- Z Displacement



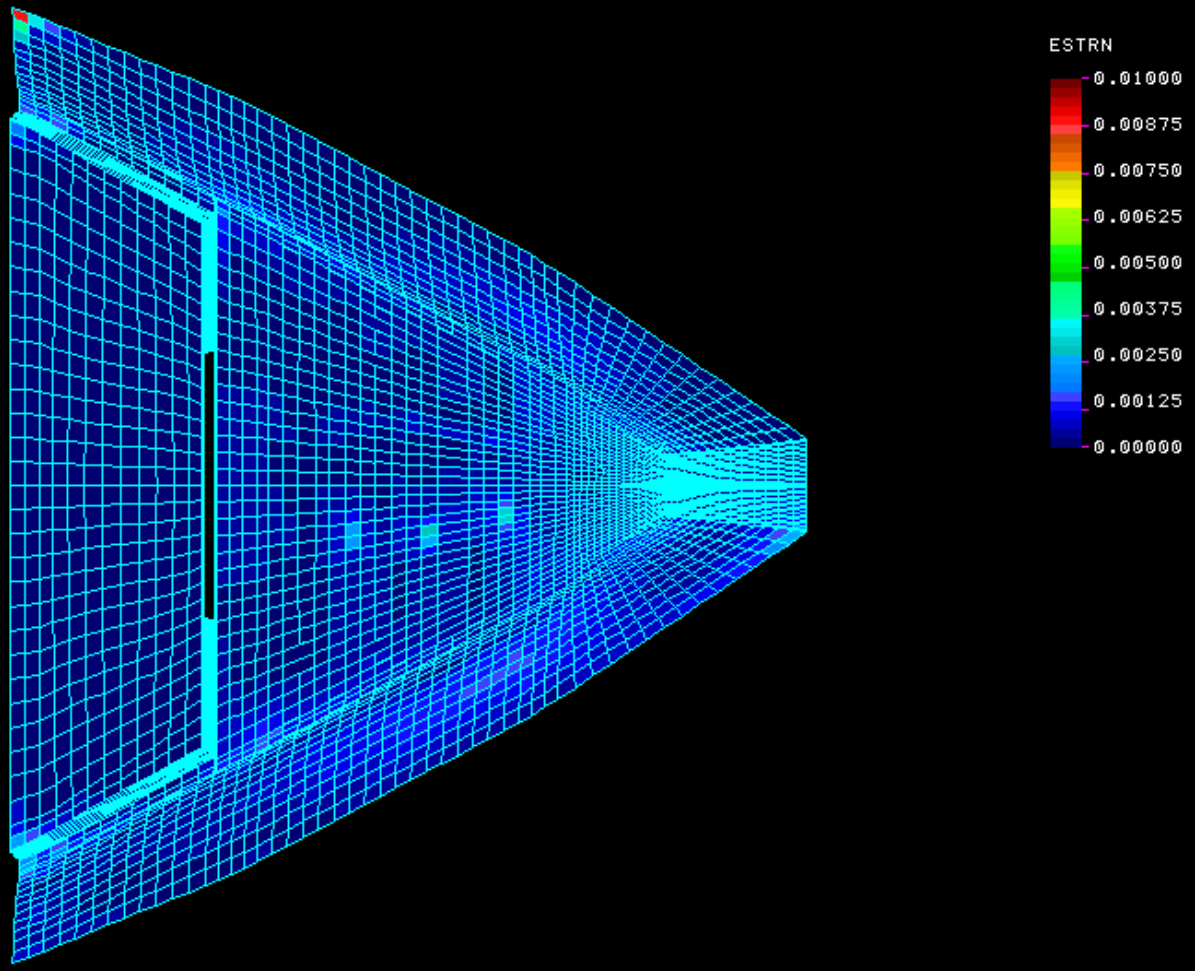
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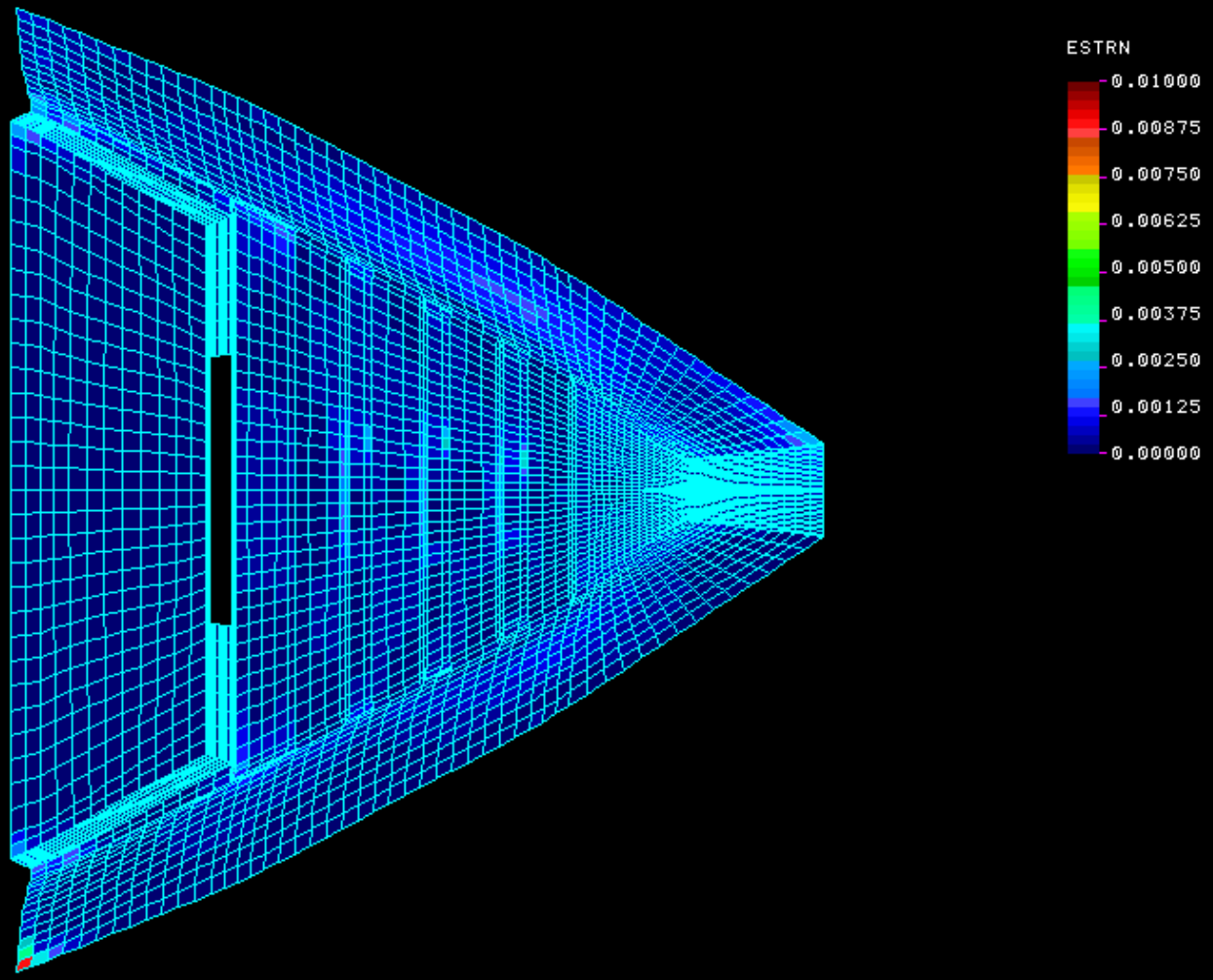
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LC10- GMT- Strain (Top View)



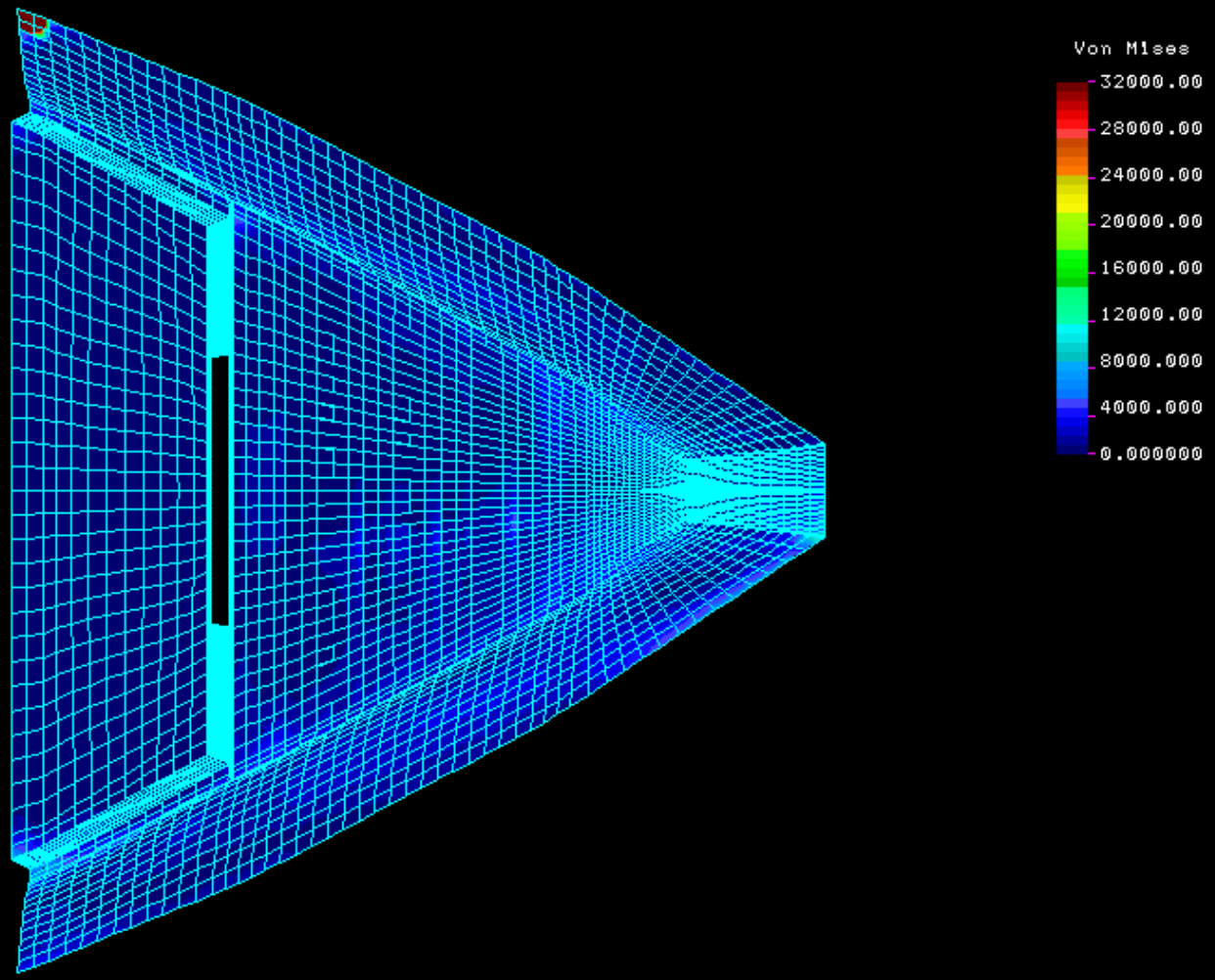
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LC10- GMT- Strain (Bottom View)



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LC10- GMT- Stress in Longitudinal Ply (Top)



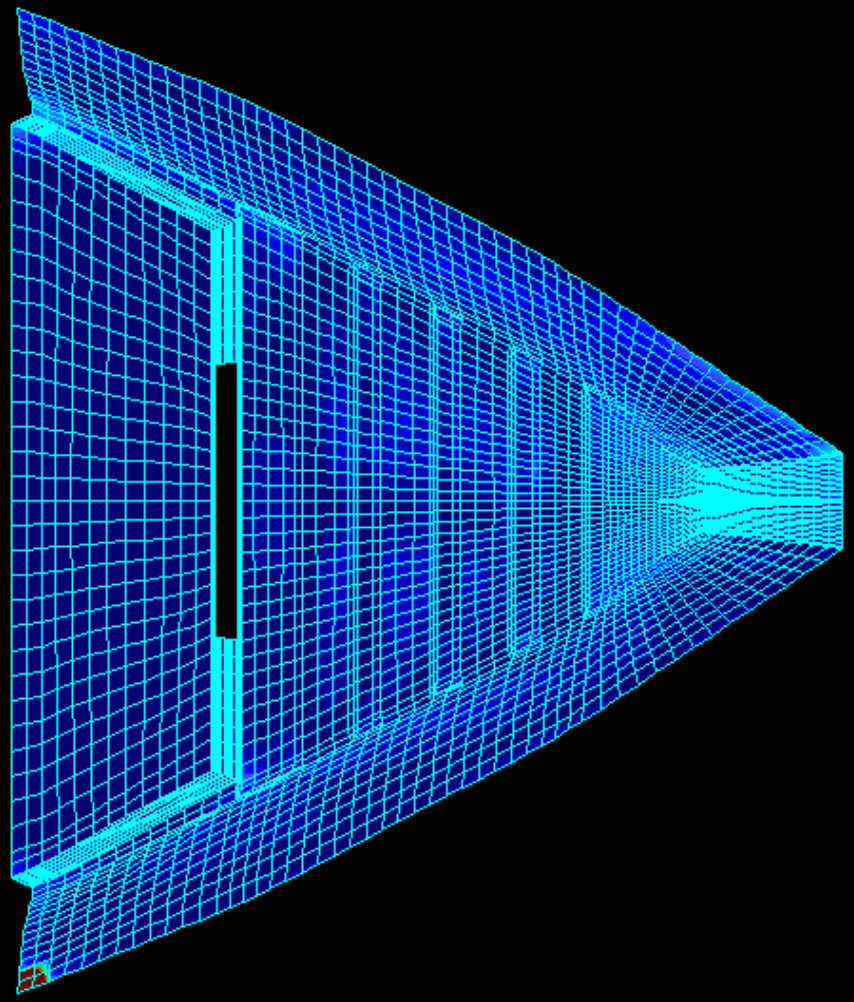
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LC10- GMT- Stress in Long. Ply (Bottom)



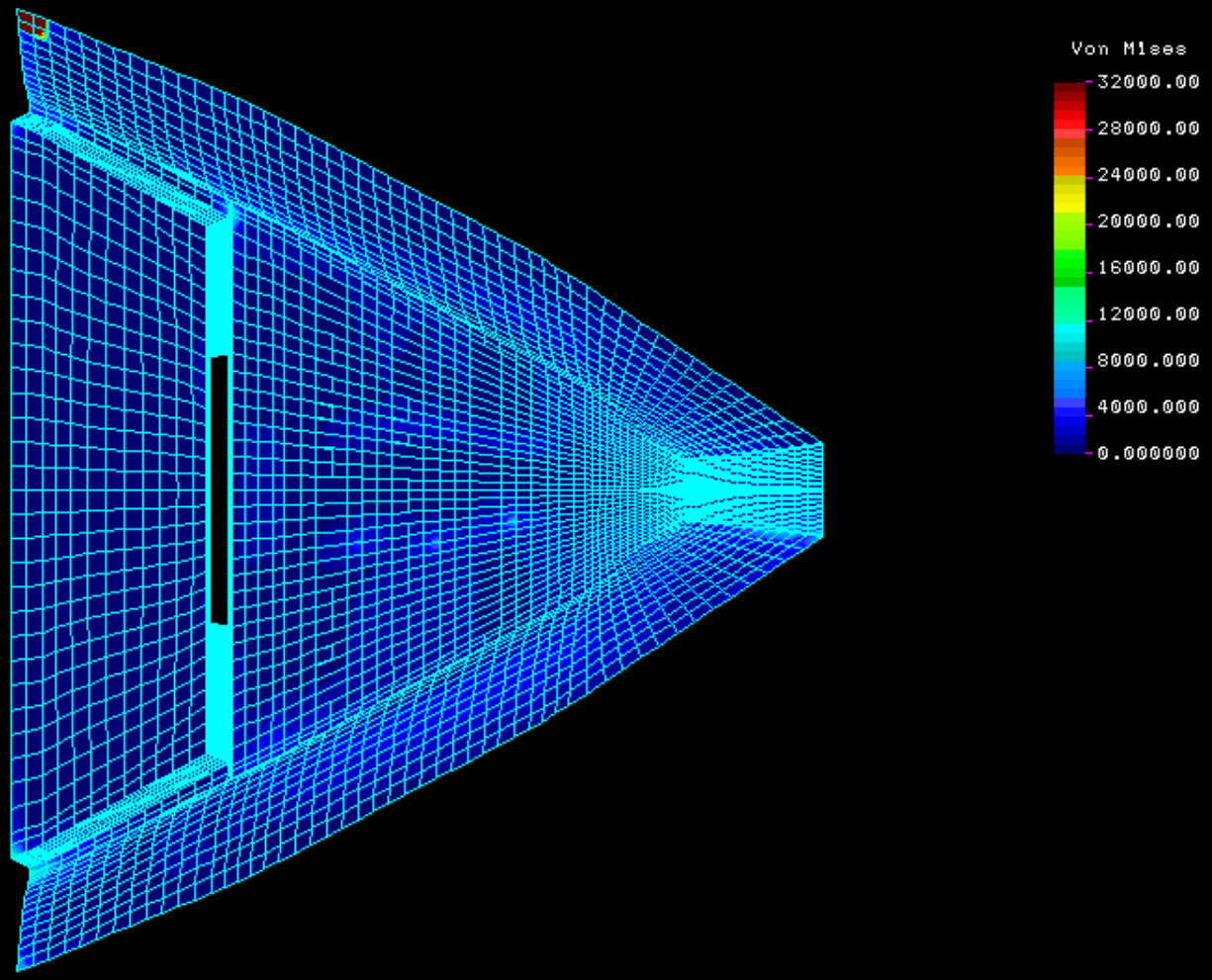
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LC10- GMT- Stress in Tran. Ply (Top)



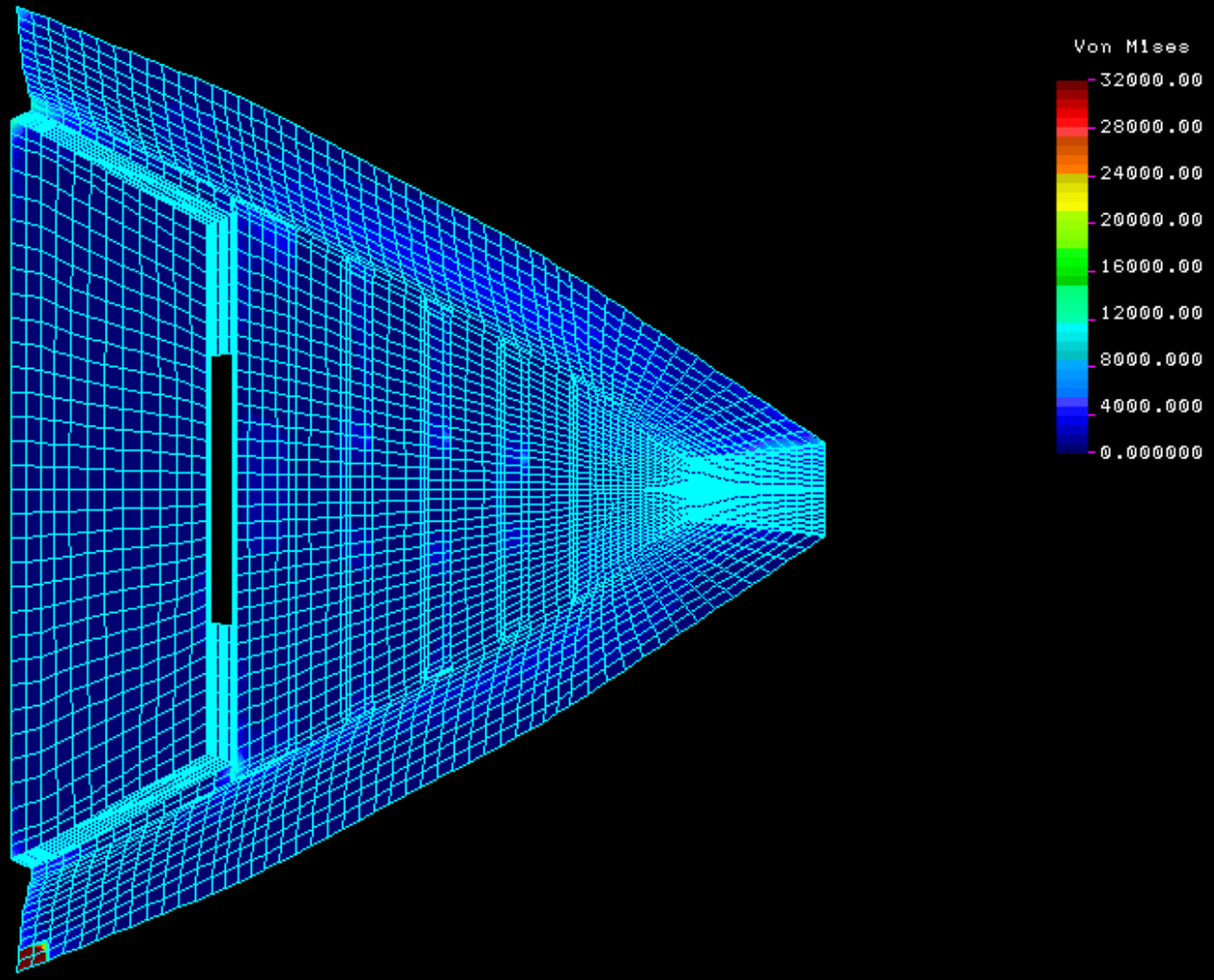
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LC10- GMT- Stress in Tran. Ply (Bottom)



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850B- G.M.T- Summary

- Range of deflection 0.25 in.
- Maximum strain .003 in./in.
- Maximum longitudinal stress 5,000 psi
- Maximum transverse stress 5,000 psi

Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
  - Slight weight increase from Rev 0
- FOS for strength in excess of 10

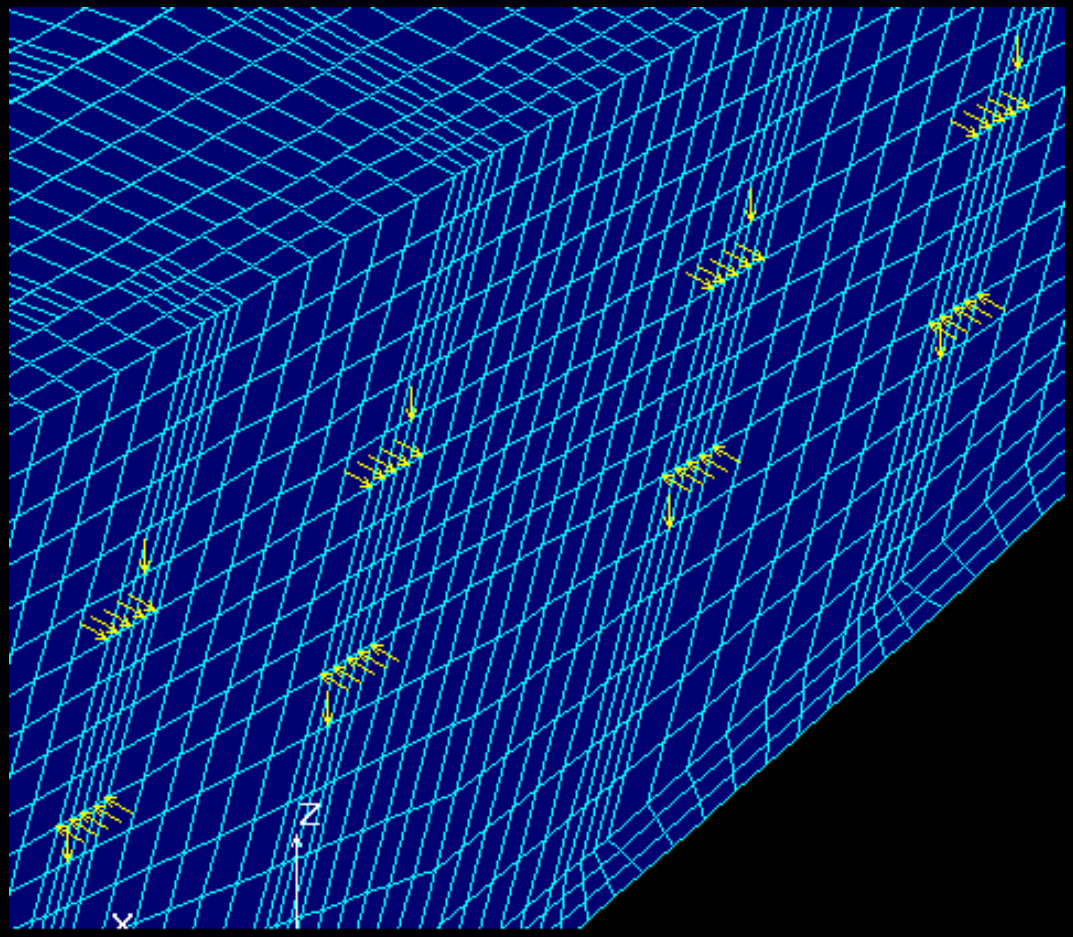
850B- FEA Analysis: Transom Load Analysis (TLA)



Transom Load Analysis-LC11

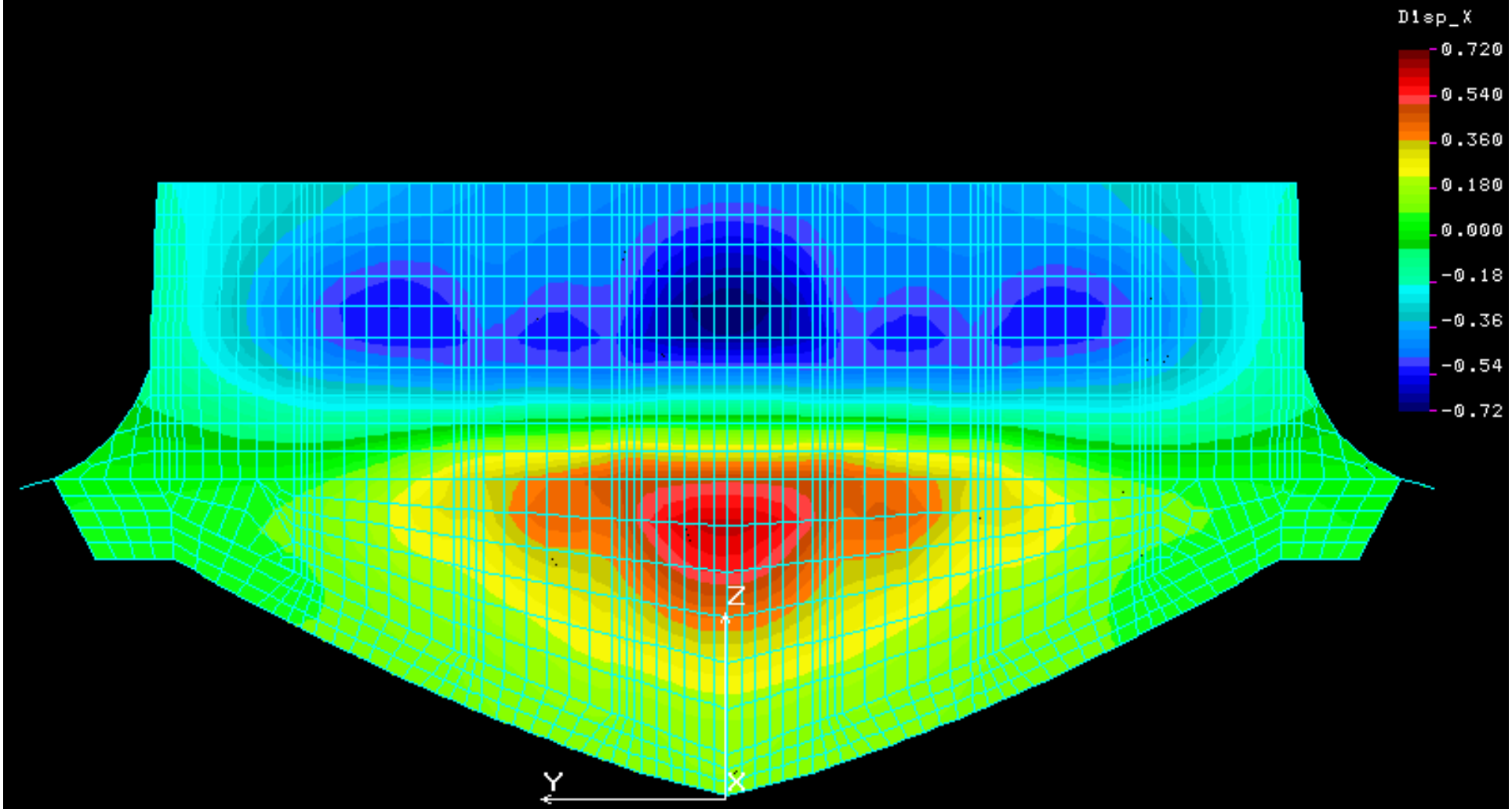
- Motor weight
  - 512 lbs each
  - Assume 3 g load, thus 1536 lbs each
  - 4 bolts for each motor
  - Applied as Z force of 384 lbf at each of the 8 mounting bolts
- Thrust of 3300 lbf for each motor (estimated)
  - 25 in shaft
  - Fx = -825 lbf on 10 nodes at top of bracket for each motor
  - Fx = 1150 lbf on 10 nodes at bottom of bracket for each motor-45) cover fabric

LC11- Transom Loads



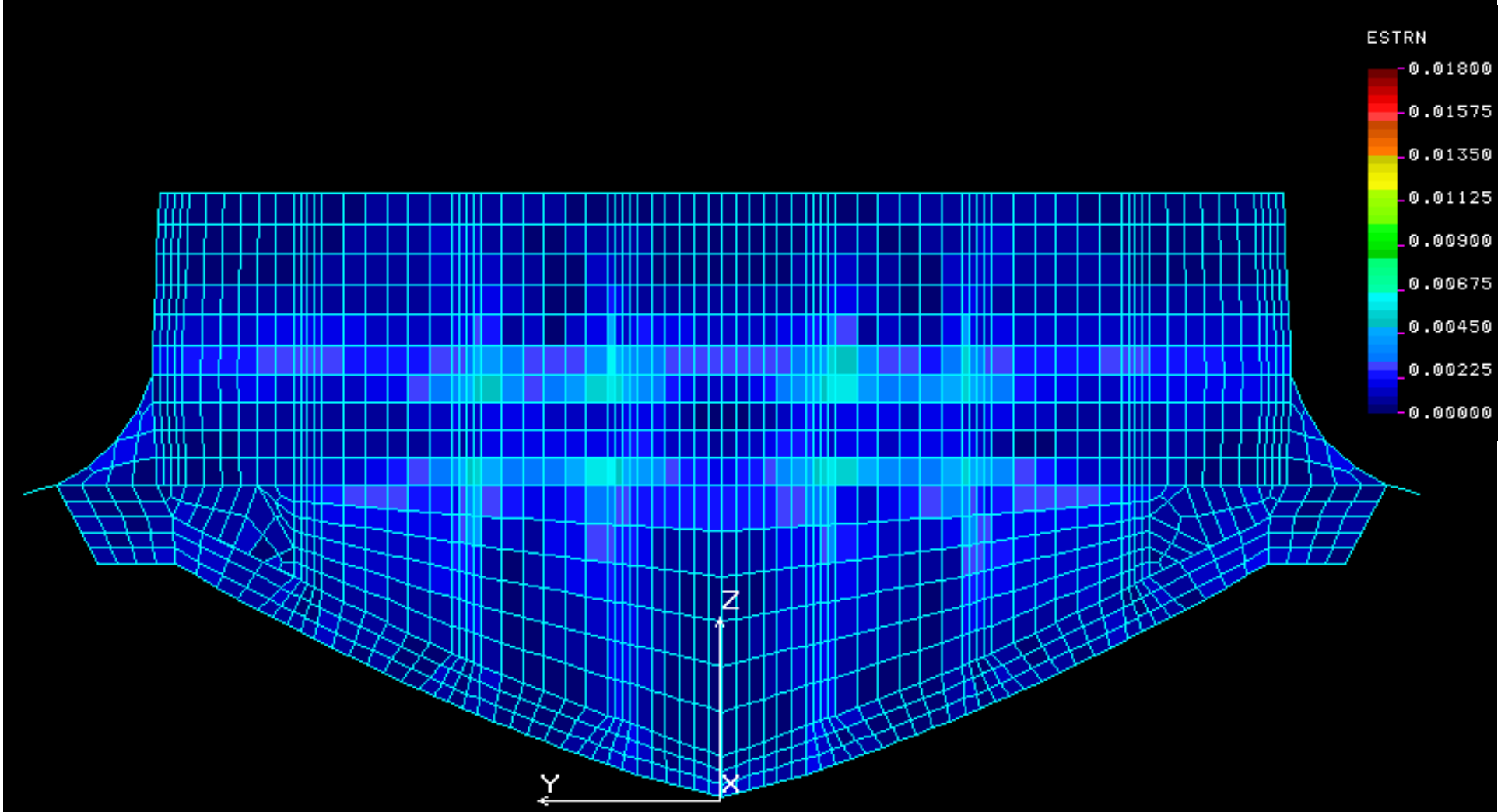
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LC11- Transom X Displacement



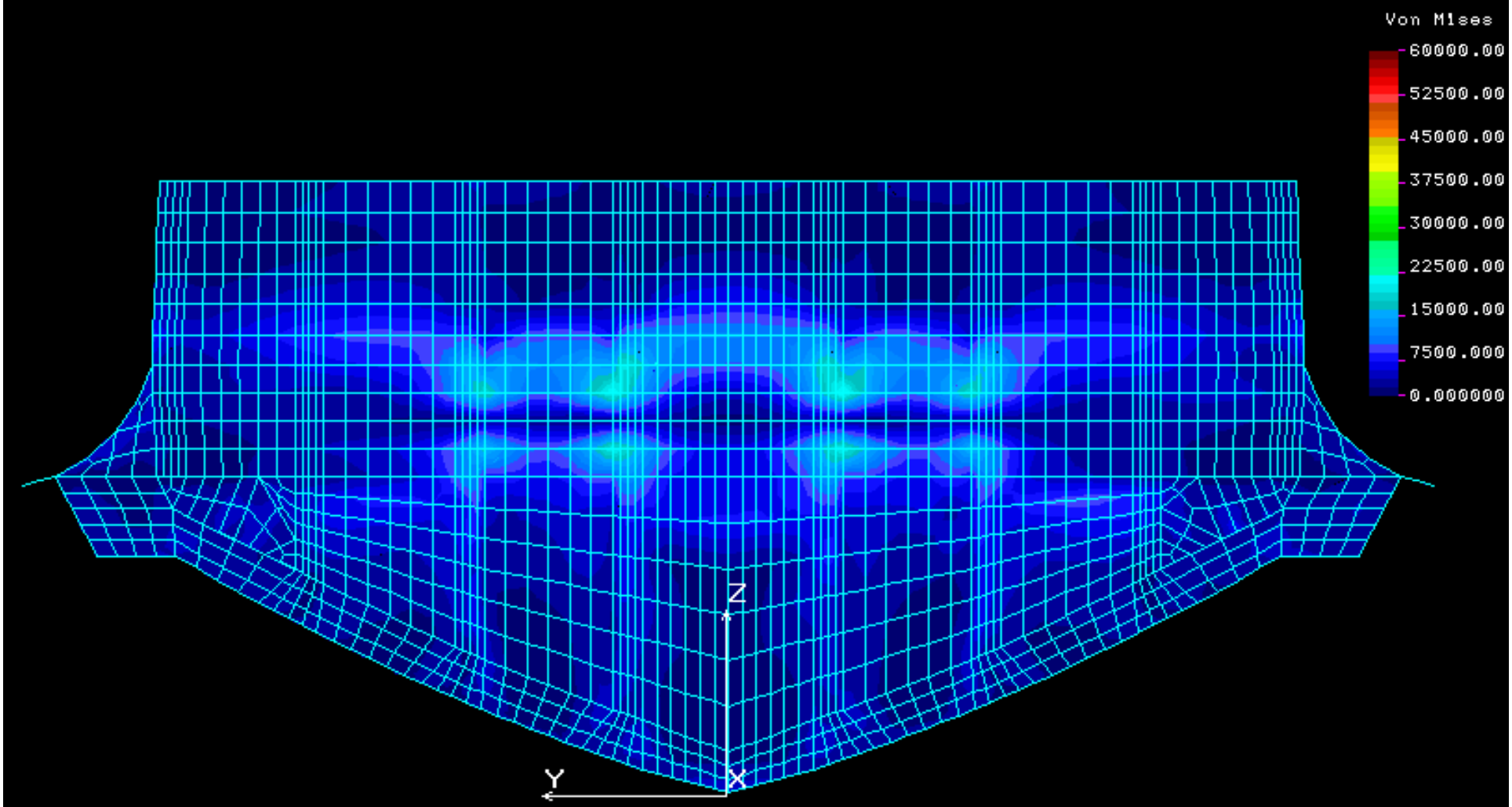
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LC11- Strain in Transom Laminate



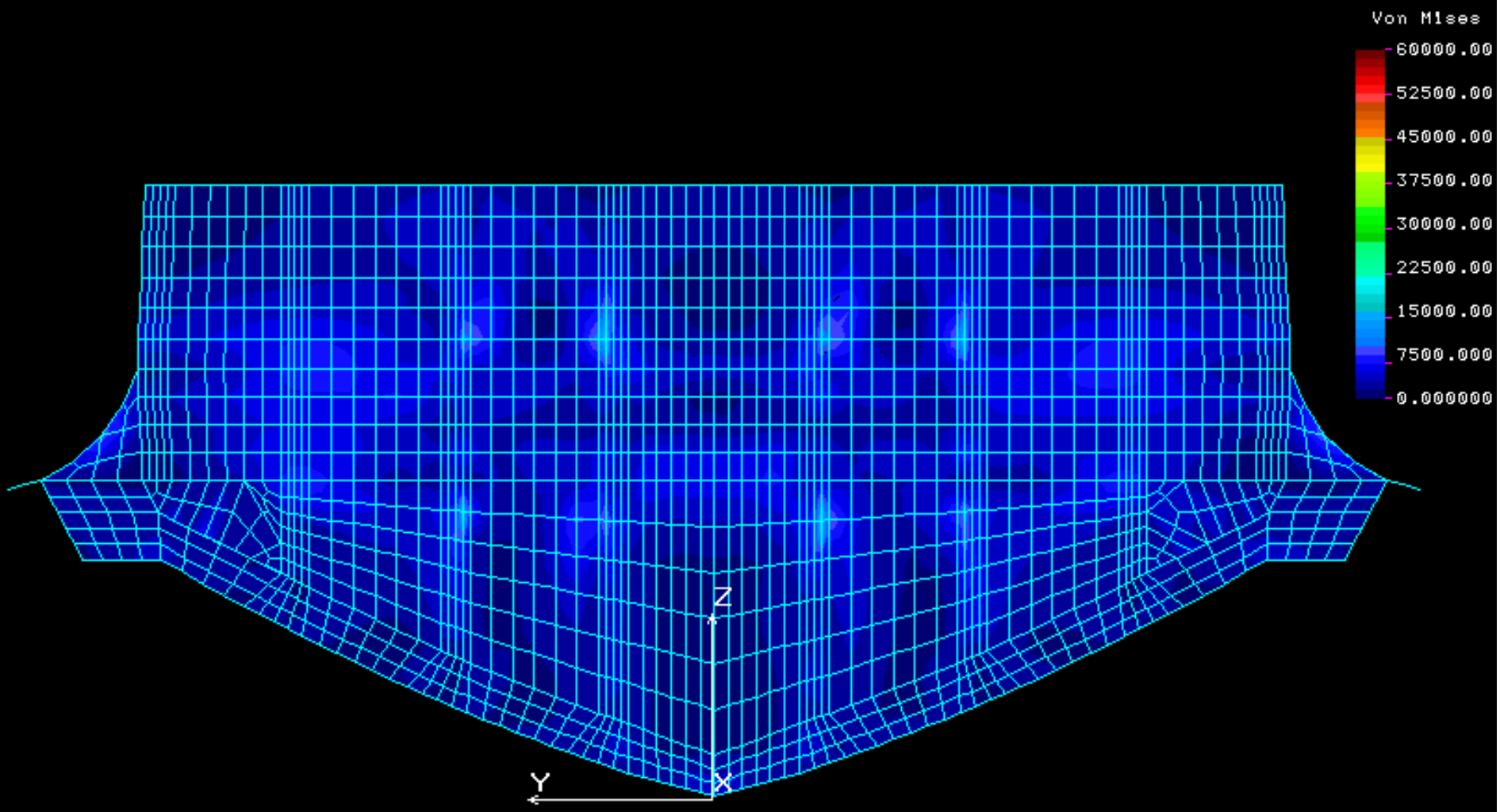
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LC11- Y Ply Stress in Transom Lamiante



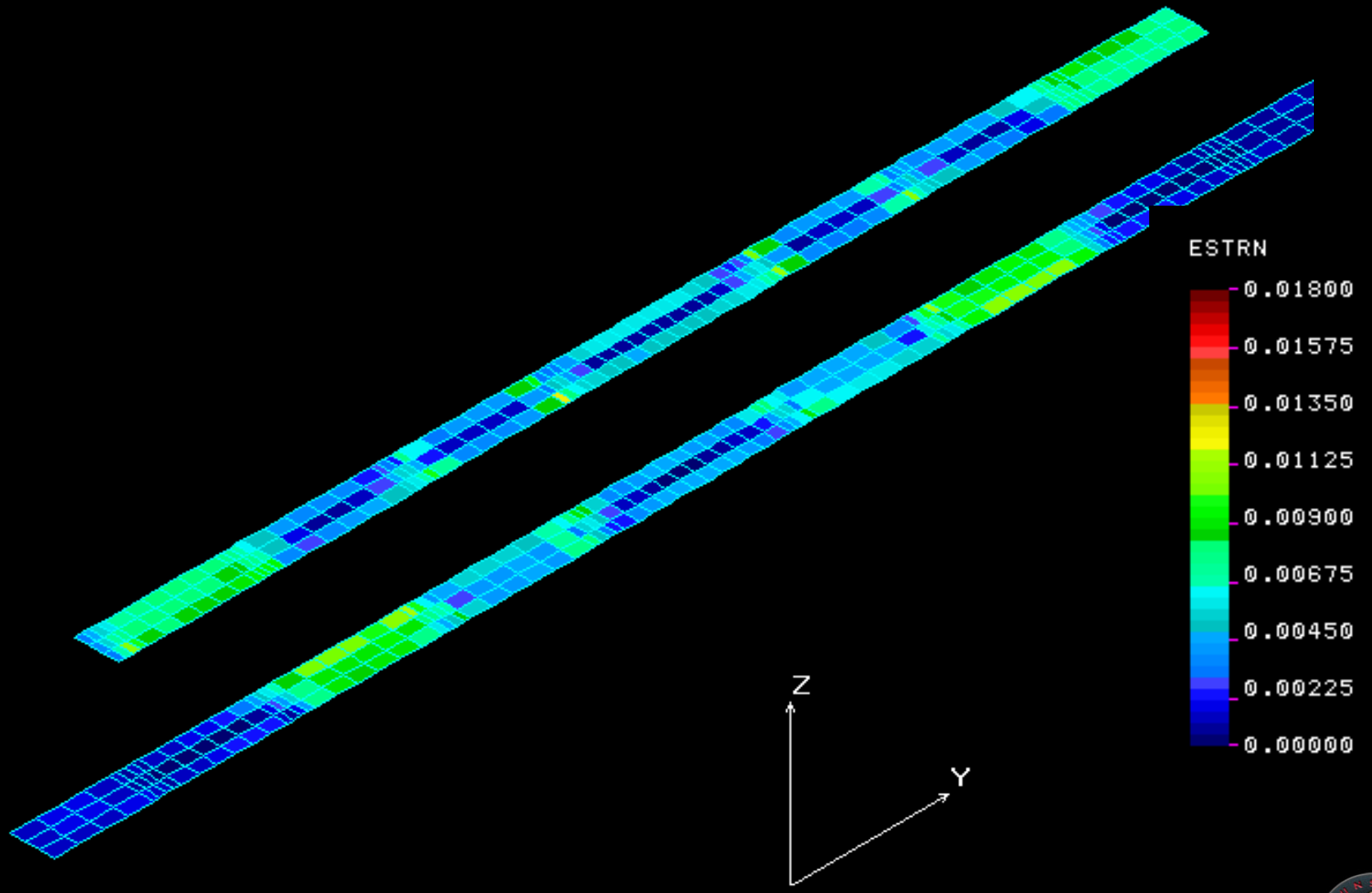
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LC11- Z Ply Stress in Transom Laminate



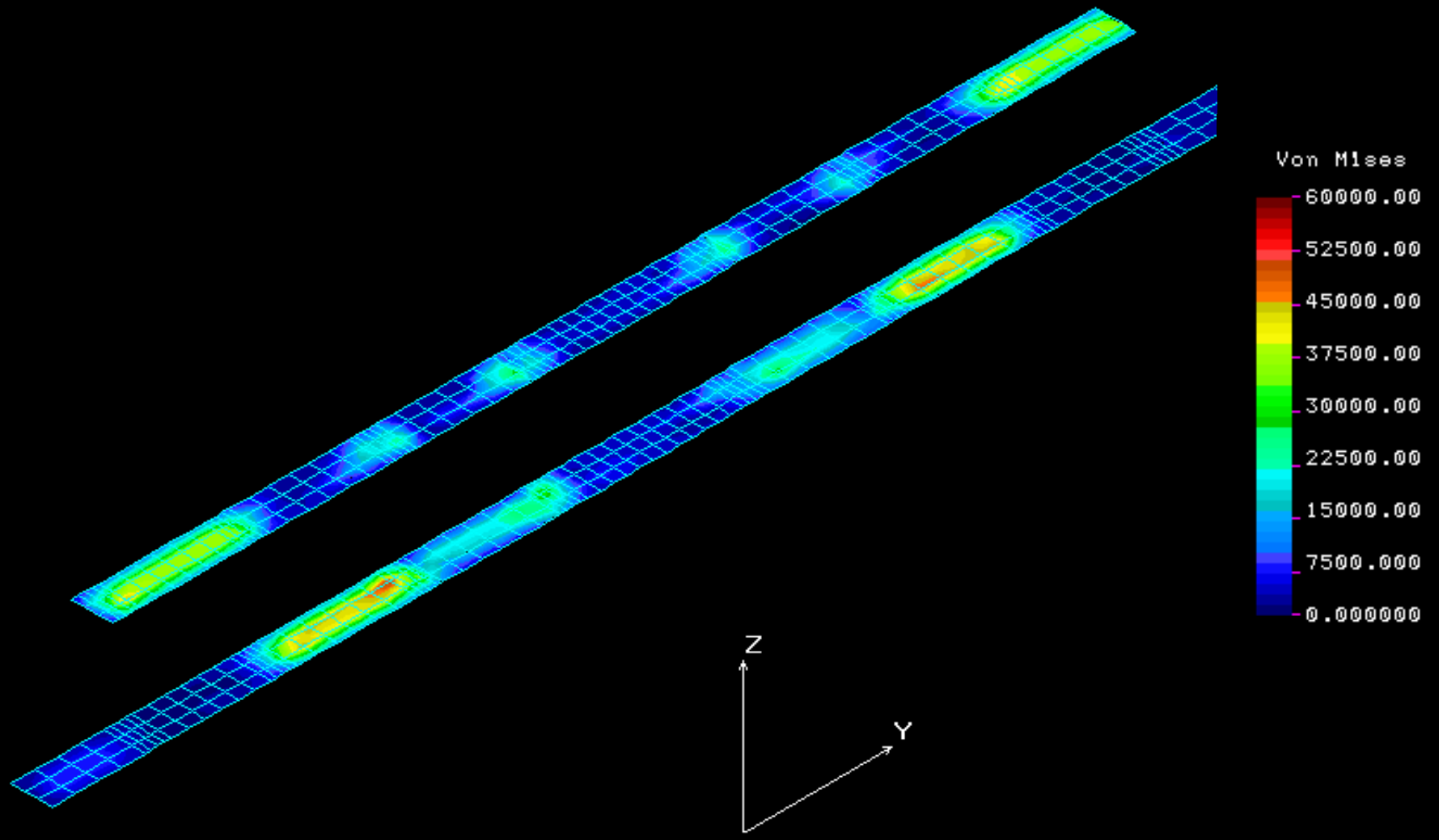
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LC11- Sear Web Strain



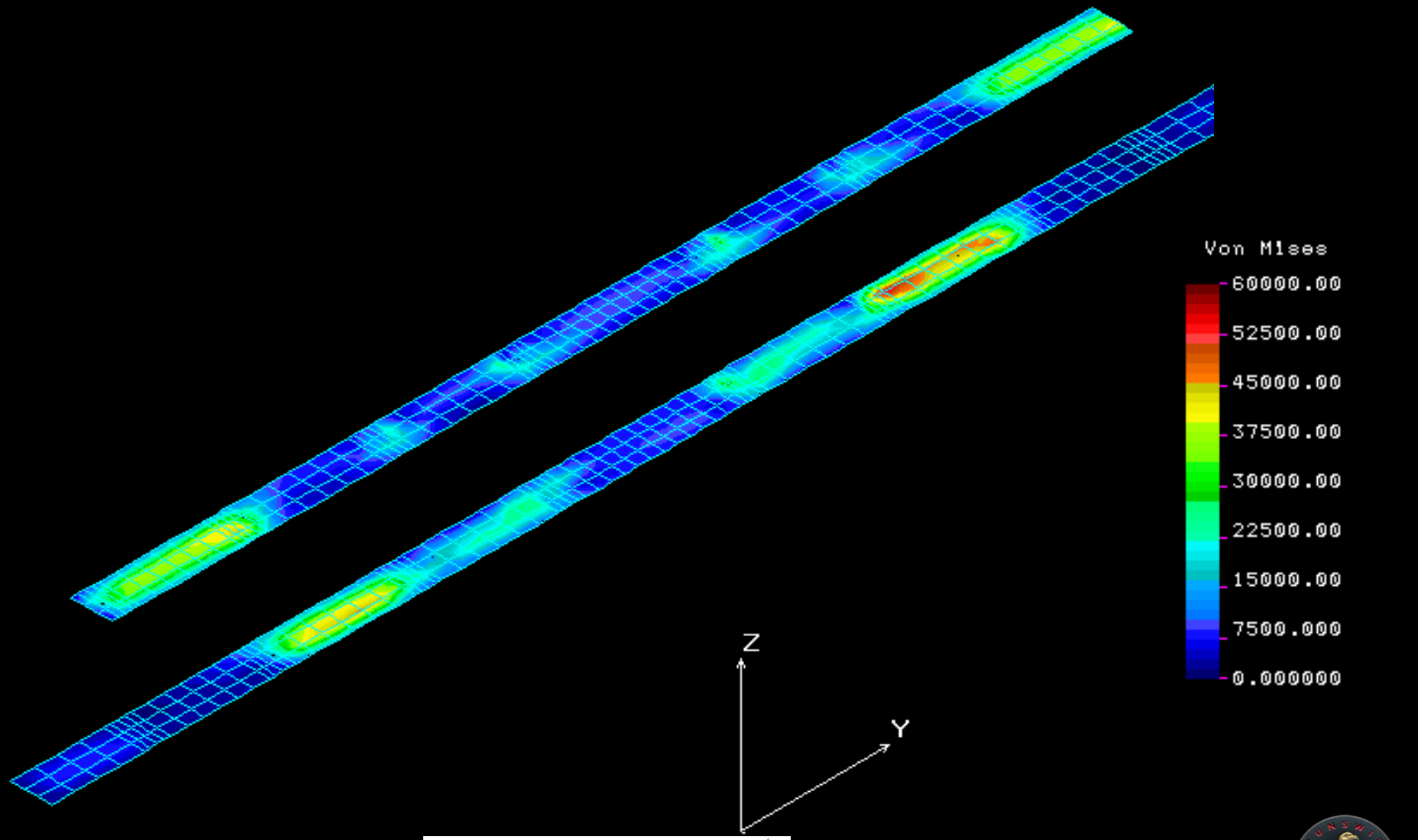
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LC11- Sear Web Stress (+45)



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ATI
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LC11- Sear Web Stress (-45)



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LC11-Transom Summary

- Transom range of deflection 0.6 to -0.7 in.
- Local panel deflection 0.2 in.
- Maximum strain 0.012 in/in
- Maximum framing stress 50,000 psi
- Maximum Transom shell stress 20,000 psi

Weight Evaluation

Boat Weights (lb)				
Segment	Baseline	850 A	850 B	850 B-OM
Fabrication Method	Open Mold	Open Mold	VARTM	Open Mold
Hull	1200	867	872	960
Deck	665	448	362	398
Console	540	350	350	350
Total	2405	1665	1584	1708
% Current	100%	69%	66%	71%
% Savings	--	31%	34%	29%

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 850A- Exceeds Metrics, On Target
  - 850B- Exceeds Metrics, On Target

850B Combatant Craft Field Test Plan



In Support of

Industrial Base Innovation Fund Contract

with

SCRA

Anderson, SC

Subcontract 2011-510

Structural Composites, Inc

Melbourne, Florida

May 2012

Scope:

The IBIF project provides for the design, development, construction and evaluation of two Navy RHIB boats. The project also funds a third design. Two of the designs are centered on the 850 RHIB currently built by Brunswick Commercial & Government Products (BCGP). The third boat is an 11 Meter RHIB built by Zodiac North America (ZNA). One 850 RHIB and one 11 M RHIB are to be constructed and evaluated as part of this project.

The 11 M RHIB will be built while instrumented sea trial evaluations of the 850B are taking place. This will allow lessons learned from the 850 to be incorporated into the boat. The 11 M design is anticipated to be a more advanced lightweight design.

Task Three of our IBIF effort provides for evaluation of the 850B prototype. The evaluation includes the performance of the craft in-water, on-trailer and during lifting. These evaluations will access the structural performance of the lightweight structure and its ability to absorb shock energy from wave impacts (Dynamic Ride Impact Mitigation, DRIM).

Structural evaluation and crew ride evaluations will be based on a combination of data collected using accelerometers, string pots and strain gauges. Accelerometers are used to scale the loading condition and the strain gauges are used to assess the structural response to the loading. This relationship can be used to extrapolate the structural response to higher loading conditions, as the relationship is linear. The string pots are to access hull and deck movement. Testing is in two general conditions. One is on-the-water operation and the other would be during transport. Both conditions will be evaluated.

850B On-The –Water Instrumentation Plan

The 850B prototype will be outfitted with devices to determine accelerations, deflection, strain, and hull cavity air pressure. In addition GPS data on speed, heading and location will be recorded. The data will be collected on a portable data collection system, recorded and post analyzed.

For the on-the –water evaluations we will place accelerometers in the following locations.

LCG- Deck and Hull (3-axis)
Helm Station- 3 axis
Hull Bottom- 3 axis (below Helm Station 3axis gauge)
Bow-2 axis (vertical) minimum
Stern- 2 axis (vertical) minimum

The design of this craft incorporates shock mitigation attributes that damp wave impact loads experienced by crew and payload. One aspect of this is the decoupling of the hull and deck of the craft. The other aspect is the low section framing that allows the hull structure to absorb wave impact energy though hull deflection. Having deflection and acceleration data will give us

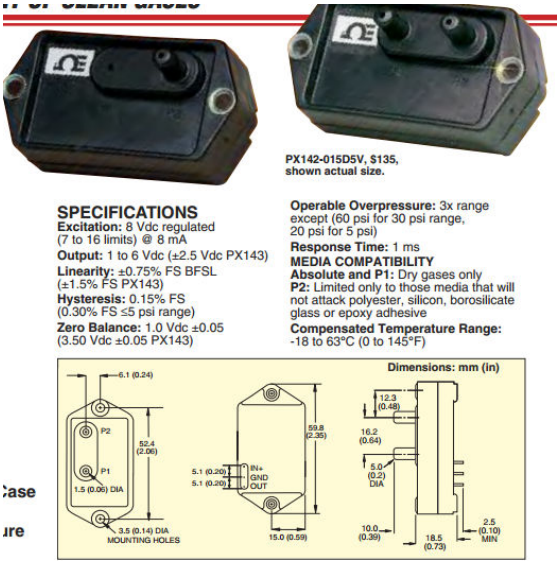
a better understanding how this new design behaves. Four Unimeasure waterproof string-pots will be installed in the craft to measure deflections.



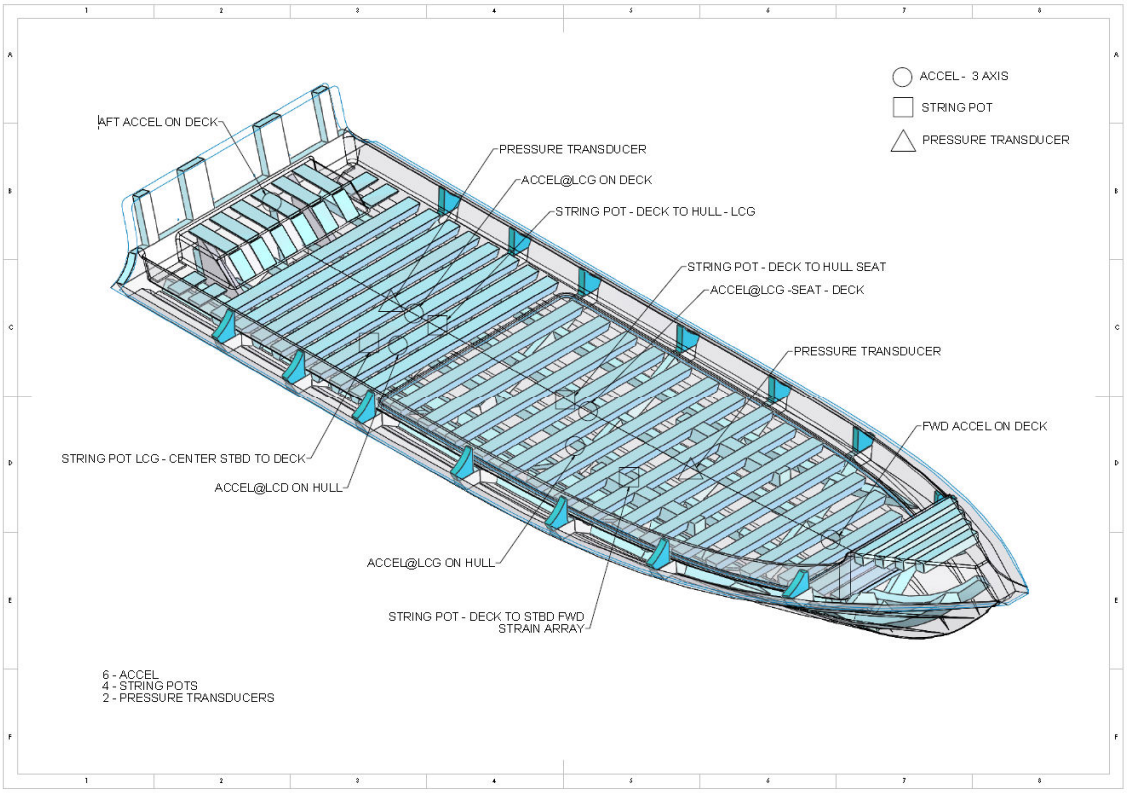
Two of these devices will be located between the keel and the deck these will be closely located to the LCG and Helm station accelerometers and two will be located between the hull mid panel and the deck. One mid-panel deflection measurement shall coincide with the location of the hull strain gauge array the other mid-panel deflection shall be to starboard of LCG.

Hull Cavity Pressure Monitoring

The design of the 850B creates an air plenum between the hull and deck. SC will perform experiments with the 850B pressurizing the hull with a 2hp air blower (1500cfm/10 in water). Hull air pressure will be monitored using Omega PX140 series differential pressure gauge (1psi range).



The figure below shows the locations of the accelerometers, string pots and pressure transducers. NOTE: the LCG is aft of the hatch and the helm is the the forward half of the hatch Also the notes show the forward accels to be at the LCG, this should be the helm station



Strain Measurements

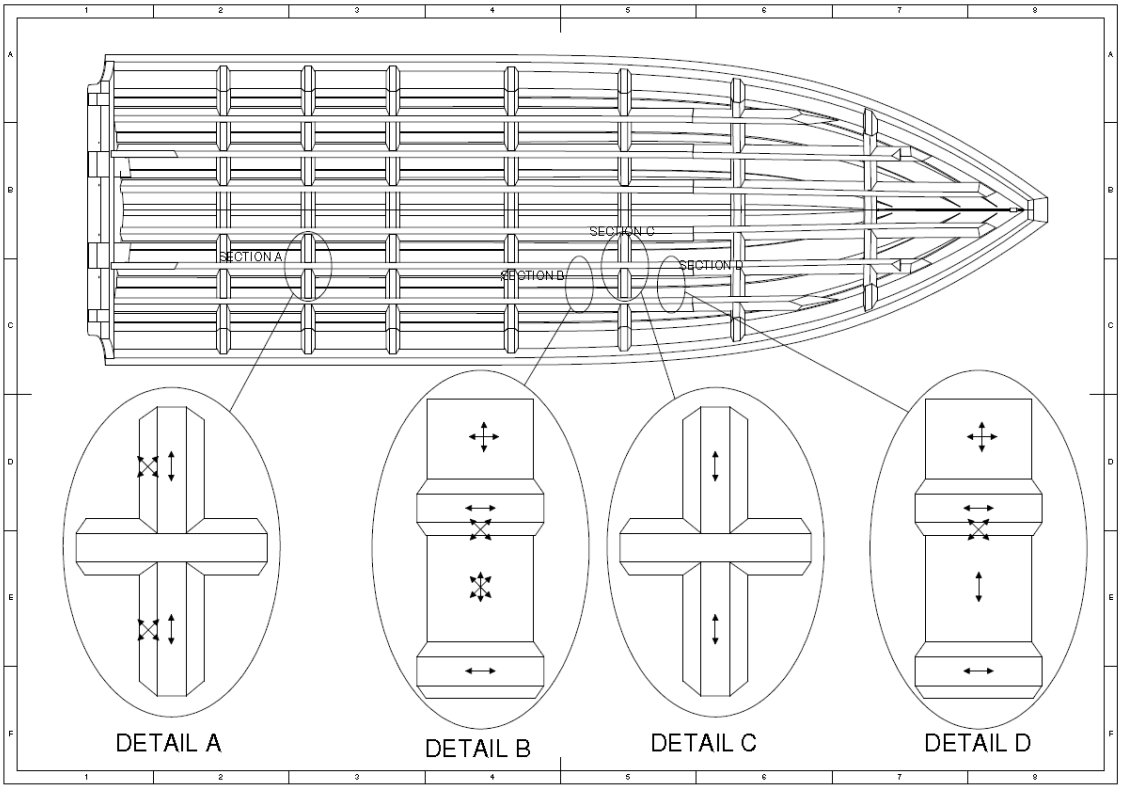
Strain gauges will be placed in key locations, in particular in areas that would be most affected by wave impact. The proposed placement at a minimum is as follows:

Cap of Stringers-impact zone forward of amidships
Transverse frame Cap- impact zone forward of amidships
Panel- edge of stringer (sidewall) – impact zone
Panel- center of panel- impact zone
Deck- FEA area of interest
Hatch- Mid-span-Cap of Frame
Transom- Sidewall of Transverse Frame

Strain Gauge Type/Location Summary

Type	Hull	Deck	Hatch	Transom	Total
Unidirectional	9	2	2		12
Bidirectional	6			2	8
Triaxial	1				1

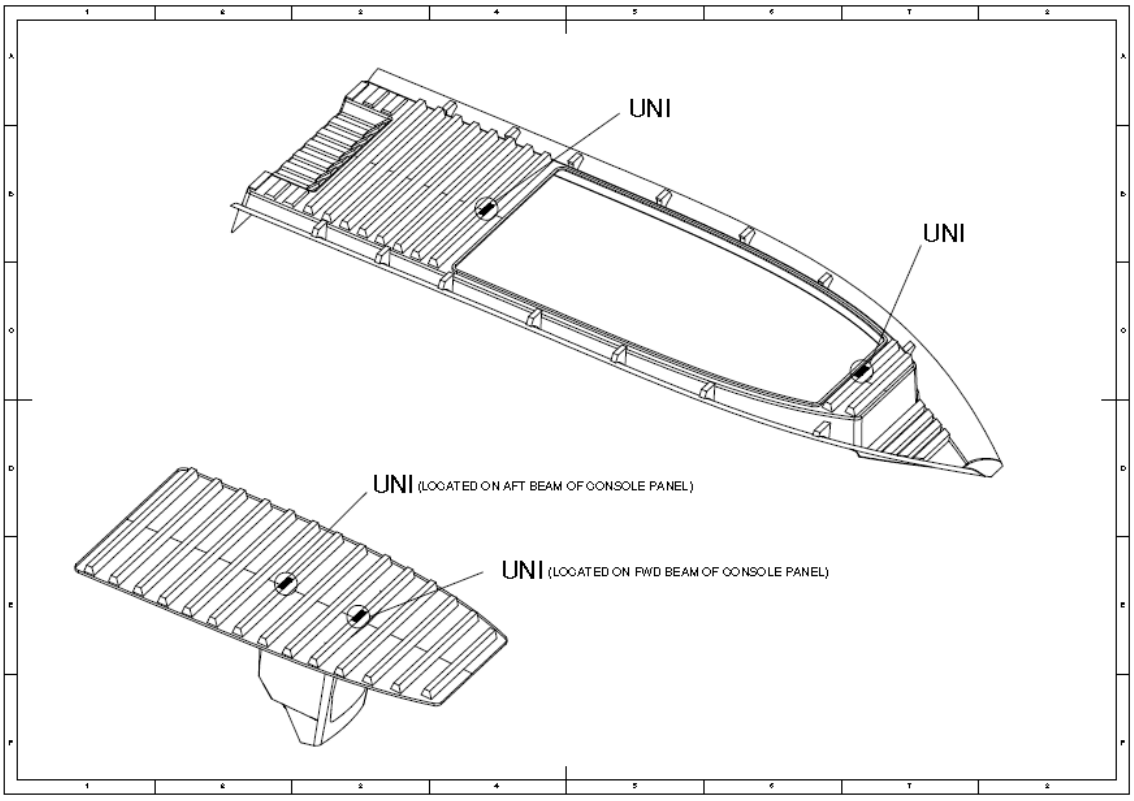
The figure below shows the location of the strain gauges for the Hull. A total of 16 gauges will be installed, 9 are unidirectional, 5 are bidirectional and 1 is triaxial. NOTE that we are not installing triaxial gauges, rather a combo of uni and biaxial gauges)



The forward hull strain gauges are configured to be able to assess the structural integrity of the hull as this is a highly loaded area during wave impact events. The gauge arrangement is configured to also allow evaluation of the hull as it transitions from bending to membrane tension. Frame side walls will utilize biaxial gauges. Frame caps will utilize single axis gauges and hull panels will around the frame use uni, bi and triaxial gauges. The location of the gauges in the test sections includes panel and frame elements that were evaluated in the FEA analysis.

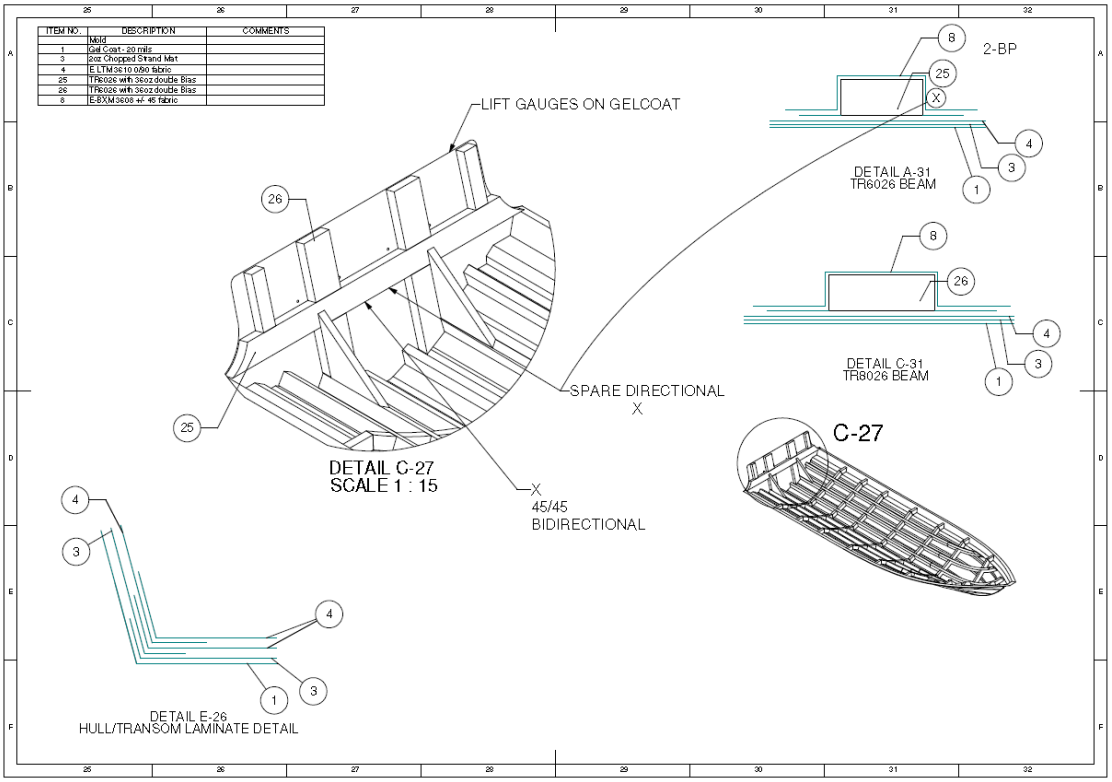
The aft hull strain gauges are configured to assess loads during transport (trailer). Two single axis strain gauges are on the transverse frames forward of the transom. Two biaxial strain gauges are located on the sidewalls of the same transverse frames.

The figure below shows the deck drawing and the location of the strain gauges. Two unidirectional gauges are to be installed on the caps of the frames with the gauge axis transverse.



The drawing above also shows the hatch components and the location of the two uniaxial strain gauges. The strain gauges are located on the frame caps oriented in the transverse direction. These frames are located in the area forward and aft of the console.

The figure below shows the transom drawing and the location of the two biaxial strain gauges. Both strain gauges are located on the side wall of the transverse frame.



Additional locations for strain gauges and/or relocation of the accelerometers will be based on field observations and the results of processed data.

Loading Conditions

Two loading conditions will be used for the evaluations. These are lightly loaded and the heaver of the fully loaded conditions. The light condition is the craft in the hoist condition. The two loaded configurations are the threshold load condition and the objective load condition. Load conditions will be achieved by adding simulated weight to the craft. The tables below show the various loading conditions. Both the VBSS objective weights and the 850B loaded weight are used.

Hoist Condition									
		VBSS Concept		**850B**	**Notes**				
		(lb)		(lb)					
	Dry Boat	4215		3630	added weight of 85 gal alumium tank				
	Fuel (50)	348		348	50 gal fuel in tank				
	Coxswain	200		200					
	PAX	800		800					
	Total	**5563**		**4978**					
				585	lbs below threshold for DDG				
				159	approx wt to increase fuel tank size to 140gal				
				426	lbs below threshold with 140gal fuel tank				
				61	gals of additional fuel (total fuel 111 gal)				
	LCG	6.8	ft	6.7	(LCG in ft without fuel or 85g tank)				

For the hoist condition the craft will be loaded to the VBSS Concept weight as it is desired to deploy the craft with the maximum amount of fuel.

Full Load Conditon Threshold									
		VBSS Concept		**850B**	**Notes**				
		(lb)		**(lb)**					
	Dry Boat	4215	w/tank	3420	dry boat no tank				
				404	appox wt of 140 gal fuel tank (linar extrapolation)				
	Fuel (140)	974		974					
	Coxswain	200		200					
	PAX	5600		5600					
	Total	**10989**		**10598**					

The full load threshold weight will be 10,600lbs and the full load objective weight will be 10,990lbs. The table below shows the 850B configured to objective weight. The difference being a desired larger fuel tank and larger fuel load. The full load objective weight will be used for the fully loaded evaluations.

Full load Condition Objective									
		VBSS Concept		**850B**	**Notes**				
		(lb)		**(lb)**					
	Dry Boat	3937	w/tank	3420	dry boat no tank				
				519	appox wt of 180 gal fuel tank (linar extrapolation)				
	fuel 180	1252		1252					
	Coxswain	200		200					
	PAX	5600		5600					
	Total	**10989**		**10991**		0.02%			

Test Runs
Two types of test runs will be performed. One series consists of a set of in water trials. The second evaluation series will be performed with the boat on a trailer.

In-Water Trials

In-water trials will include controlled wave jumping and at sea runs. Prior to data collection a series of shake down runs will be made. Initially these runs will be done under the supervision of the boat manufacturer. This will allow us to understand the boats overall performance, capabilities and conditions for safe operation. Following shake down trials the boat will be run in the inter-coastal waterway and will consist of a series of runs over a large boat wake. The boat will be run though the wake under the following headings; bow, bow quarter, stern, stern quarter. The boat will be evaluated in the light and threshold fully loaded condition. For each condition a series of trail runs will be made at increasing speed. Once the maximum safe speed is determined a minimum of six repeat runs will be made.

Sea Trials

Sea trails will be conducted within reasonable range (1-2nm) to a NOAA weather buoy. Sea state between 2 and 3 is desired. The boat will be loaded in the threshold fully loaded condition. The boat will be tested bow and bow quarter. A series of ocean trails will be run to determine maximum safe operational speed. Runs or a series of runs will be made so that at least 250 wave impact events are recorded for each heading. As time and conditions allow, additional runs in the stern and stern quarter will be collected. In addition as time and budget allows additional runs in the light condition and objective fully loaded condition will be made. In the light and objective load conditions preference is on bow and bow quarter runs.

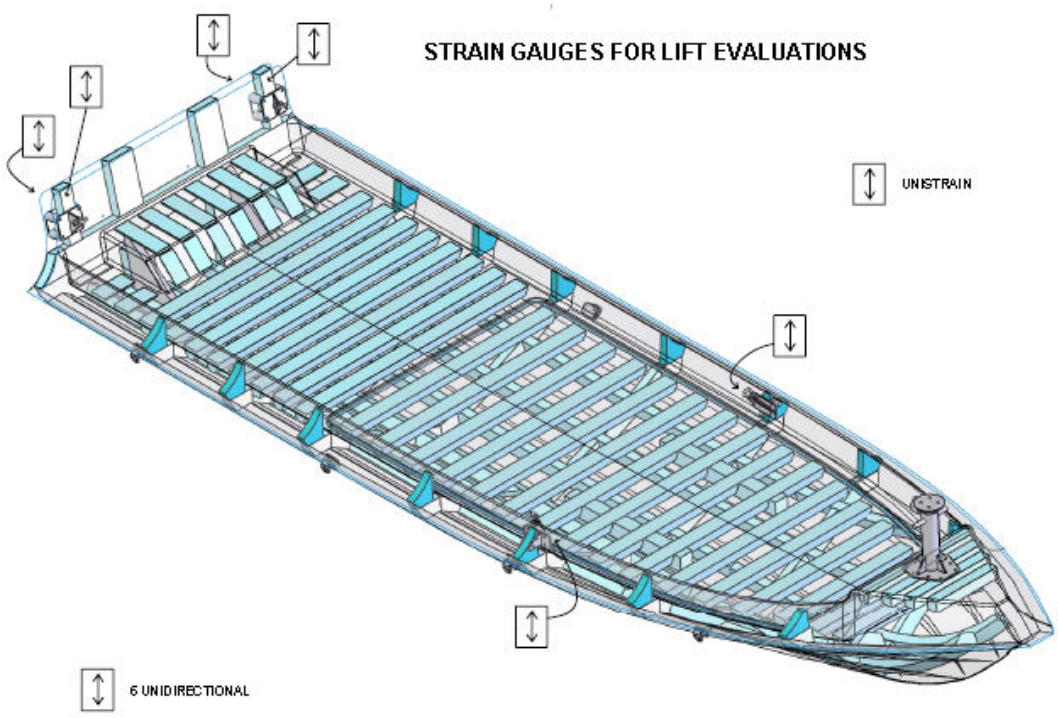
Additional In-Water Trials
As time and budget allows additional runs will be made. Desired runs include operations in severe wave conditions such as outgoing tide in inlet and/or wave jumping over a known ocean shoal and trials to evaluate the air support concept. In water trials of the pressurized hull are also desired.

Trailer Evaluations
During trailer evaluations the boat will be instrumented in a slightly different fashion than the in-water evaluations. Strain gauges will be installed on the transverse frames, as the bunks will impart greater load on these. The bow, stern, helm, and hull accelerometers will stay in place. An additional single axis accelerometer will be located on the boat trailer.

The boat will be tested under normal and extreme conditions. The boat and trailer combination will be towed over a paved road in poor condition at 35 mph, a dirt road in poor condition at 20 mph, and towed over curbs and parking stops at up to 10 mph in a parking lot

Lift Evaluations

The crafts structure will be evaluated in the lift condition. Strain gauges will be placed in key locations as shown in the drawing below. The craft will be loaded so that the weight is 5600 lbs. The craft will be lifted using the suppler provided lifting sling. Data will be collected from the strain gauges.



Data Collection and Use of Collected Data

In addition to assessing structural adequacy, the acceleration and strain data will be used to evaluate the structures ability to transition from conventional bending to membrane tension. Gaining a better understanding of the loading required and the structural response during transition to membrane tension are important drivers to optimizing this new design approach and learning how to model and later extrapolate the design to other craft.

To the extent possible, data will be processed and evaluated per NSWCCD-23-TM-2010/13 titled "A Generalized Approach and Interim Criteria for Computing A 1/n Accelerations Using Full Scale High Speed Craft Trials Data". By Michael R. Riely, Kelly Haupt and Donald Jacobson. Specifically we will collect data at 100 hz and use a 10hz filter. We will compute the average of the $1/10^{th}$ highest peaks using the filtered data.

Data Collection and Analysis

We will use our high speed data collection system. This system is capable of sufficient sampling speed so that we can capture wave impact events and trailer shock load events. The data will be used to better understand the structural response of these new designs and to access structural adequacy of the vessels. We anticipate collecting data at 100hz on each sensor channel.

Succeed/Pass Fail Criteria

Our design goal was to have in service strain rates less than 30% of the linear elastic range of the structural materials. This strain based criteria has been selected as a conservative level that historically results in good fatigue life. A combination of coupon, panel response and field test data will be used to determine the strain rates that designs will experience. Acceptance will be in agreement with the TPOC.

We will also evaluate the difference in accelerations between the hull accelerometer and the accelerometer on the deck directly above. This difference will give us a good idea on how the hull structure is mitigating shock loads. Data will be processed using the NAVSEA filtering approach and other methods as the data dictates.

As time, budget and opportunity allows we will attempt to get deck acceleration data from an 850 baseline boat. Ideally we would like to run the baseline with the 850B side by side.

Structural Composites Inc.

Hoist Overload Test

CLIENT:	---
TESTS PERFORMED:	Hoist Overload
TEST PROGRAM NAME:	IBIF 850B
DATE TESTS PERFORMED:	8/14/2012

TEST LOCATION :

Structural Composites
7705 Technolgys Drive
West Melbourne, 32904

Design Safety Factor (Ultimate) :	6
Design Hoist Condition Weight :	5,600 lbs
Proof test required :	150%
Total Proof Load Required :	8,400 lbs
Numer of lifting eyes tested at once :	4
Minimum Load Required :	8,400 lbs
Actual Load Witnessed :	8,593 lbs

Weight of Hoist Test Breakdown

Item	Item Weight	Amount	Total Weight
Empty Boat Weight	3885lbs	1	3885 lbs
(Includes weight of fuel onboard at time of test)			
Empty Water Bag Weight	10lbs	6	60 lbs
Fresh Water Weight	8.3lbs/g	560	4648 lbs
		Total Hoist Weight	8593 lbs

Table 1: Lift Test Procedures (Hoist Load or 150% Overload Test)	
Step	Description
1	Place water bags around hoisting point center of gravity
2	Connect rigging to hoist fittings
3	Fill the water bags with the determined amount of water
4	Lift the boat up untill it is completely off the trailer (only by a few inches)
5	Let the boat settle for a minute and lift it higher to compensate for the straps streaching
6	Hold it there for 10 minutes
7	Lower the boat back on the trailer
8	Visually inspect all lugs

Table 2: Lift Test Results	
Test Date	14-Aug-12
Test Loacation	7705 Technolgys Drive, West Melbourne, FL 32904
Hoist Start Time	11:45
Hoist Stop Time	11:57
Total Hoist Time	12 Minutes
Hoist Load	8593 lbs
Engineer	Eric Roehl

Responsible Engineer: _____

Eric Roehl - Director of Testing Services

Date Signed: 9/4/12

Sling and Fitting Overload Test Report

Summary

The lifting test, done at Structural Composites for the 850B test boat, was designed to test the hoist sling and fittings at the designed maximum overload hoist weight for a more accurate loading condition compared to how Brunswick Commercial & Government Products load and test the hoist fittings.

Hoist Test Procedure

Brunswick Commercial & Government Products load and tests the hoist fittings on boats by strapping them down to the ground and then using a crane, start pulling on the hoist fittings. While this does a great job at testing the hoist fittings for boats whose deck and hull are connected with cores, it does not provide a true hoist test for this prototype 850 boat whose deck and hull are only attached around the edges. To test the hoist fittings it was decided here at Structural Composites to load the boat with weight on the deck and then lift the boat using the hoist fittings up to 8500lbs. This was done by placing water bags around the deck, and the amount of water added to the bags was regulated using a meter. Then hoisting the boat up and holding it there for 10 minutes, and adjusting the height as necessary allows the boat to get a true hoisting test and keep it off of the trailer.

Table 1: Lift Test Procedures (Hoist Load or 150% Overload Test)

Step	Description
1	Place water bags around hoisting point center of gravity
2	Connect rigging to hoist fittings
3	Fill the water bags with the determined amount of water
4	Lift the boat up untill it is completely off the trailer (only by a few inches)
5	Let the boat settle for a minute and lift it higher to compensate for the straps streaching
6	Hold it there for 10 minutes
7	Lower the boat back on the trailer
8	Visually inspect all lugs

The weight of the outfitted boat currently is 3885lbs, the weight of the water bags (6 at 10lbs each) is 60lbs, the weight of fresh water is 8.3lbs/gal, and the amount of water used was 560 gallons, which totaled to the entire hoisting test was done at 8593lbs.

Results

The results of the lift test measurements for the overload test are listed in the table 2.

Table 2: Lift Test Results

Test Date	14-Aug-12
Test Loacation	7705 Technolgys Drive, West Melbourne, FL 32904
Hoist Start Time	11:45
Hoist Stop Time	11:57
Total Hoist Time	12 Minutes
Hoist Load	8593
Responsible Engineer	Eric Rhoel

This test mimics all of what Brunswick does to test their boats with the exception of hoisting the loaded boat compared to strapping the boat down and pulling on the hoist fittings. After visually inspecting the boat and not seeing any cracks or breaks after both this test and the one performed by Brunswick, it is acceptable to say this boat passed the hoisting tests.

850B- River Trial- Single Engine and Heavy Load Performance Trials

- Narrative-

Scott Lewit-President Structural Composites, Inc.

Trails- 10 July 2012- Indian River Lagoon- Sebastian Inlet- Florida

The 850B was taken out for water trials on 7/10/12. The 850B is a lightweight design that features all single skin construction and a suspended cockpit to mitigate shock loads due to wave impacts. The 850B prototype has hull and deck structure that is 40% lighter than the baseline craft. In addition, the craft is outfitted with lightweight high performance JP fuel outboards. The result is lightweight RIB with a high power to weight ratio.

The goal of this trial was as follows:

- Determine Performance with a Single Engine
- Determine Performance Under Full Load

The two 25 gallon portable tanks were filled. For Hoist load 1100 lbs of water was added to two water bladders, these were located on the deck forward of the fuel tanks. For the full load condition an additional 5,500 lbs were added (660 gal water +bag weight). In the Hoist condition total craft weight is 5,500 lbs and in the fully loaded condition total weight is 10,990 lbs

As the craft was configured for the hoist condition we first did the single engine trial run. The Port engine was in simulated engine failure mode; the engine was turned off and tilted up out of the water.



Figure 1. 850B in single engine configuration-simulated engine failure

In this configuration the craft was run at full throttle to determine maximum speed. The maximum speed we obtained under single engine power was 36.5 MPH. Other performance metrics are included in the charts that follow.

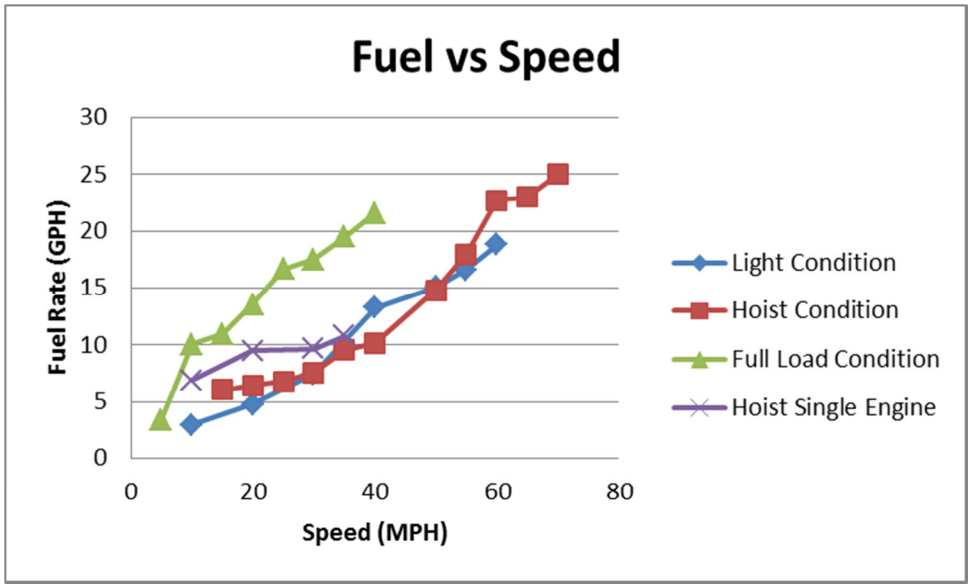
After this run 6 additional 100 gal water bags were placed in the boat. Two bags were placed outboard of the fuel tanks. Two bags were placed on either side of the console and two bags were placed on the deck in the bow area. All but one of the two bow bags were filled with 100 gal this includes the two bags used for the hoist weight. The 2nd bow bag was filled with so that a total of 790 gallons of added weight were placed.

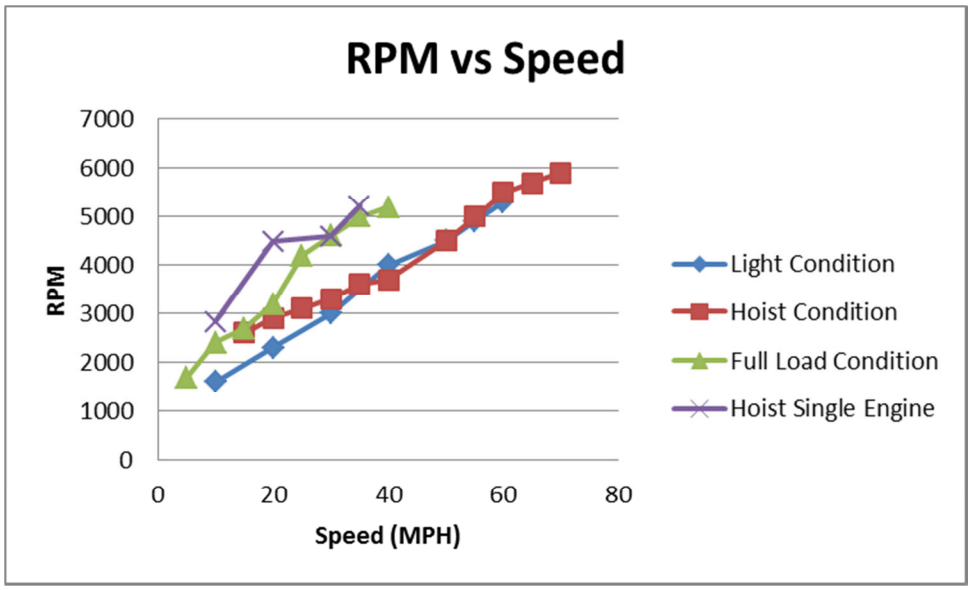


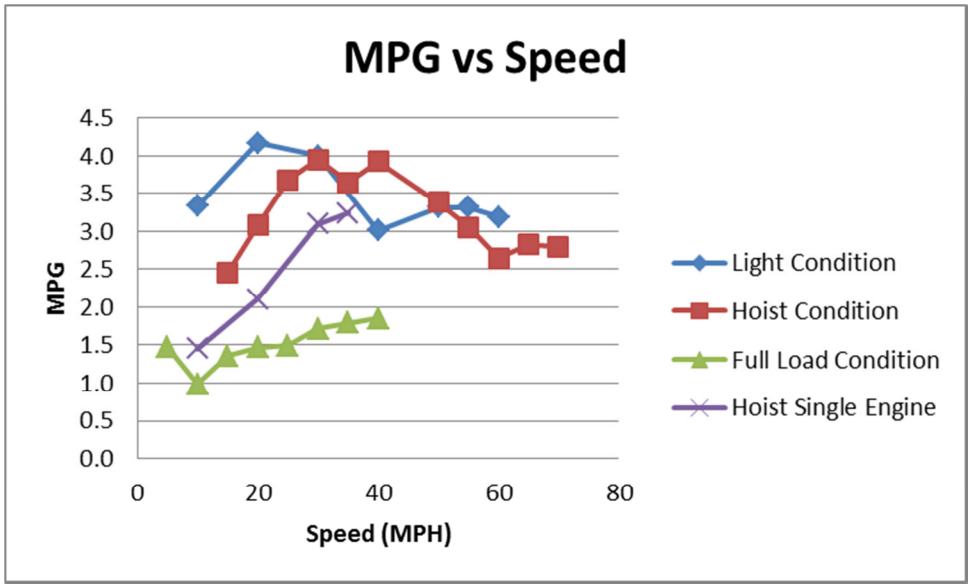
Figure 2. Meter hooked to bilge pump to fill water bags

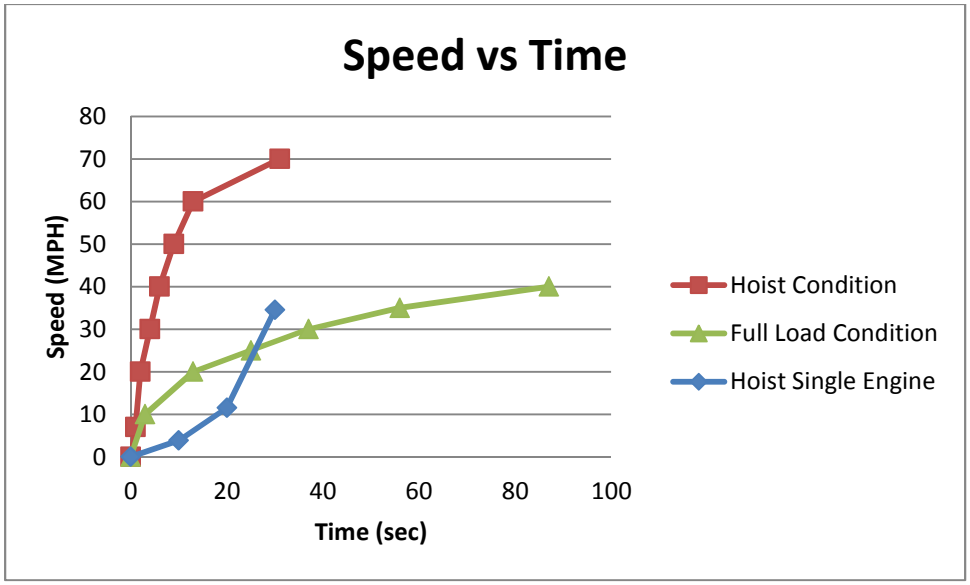
The 850B was run in the full load condition to obtain performance metrics. In this configuration the top speed obtained was 40 MPH. It was noted that the craft acceleration was greatly reduced and trim tabs were used to help the craft get on plane. It was also noted that at this weight the boat had a more damped feel. Maximum RPM that could be achieved was 5300.

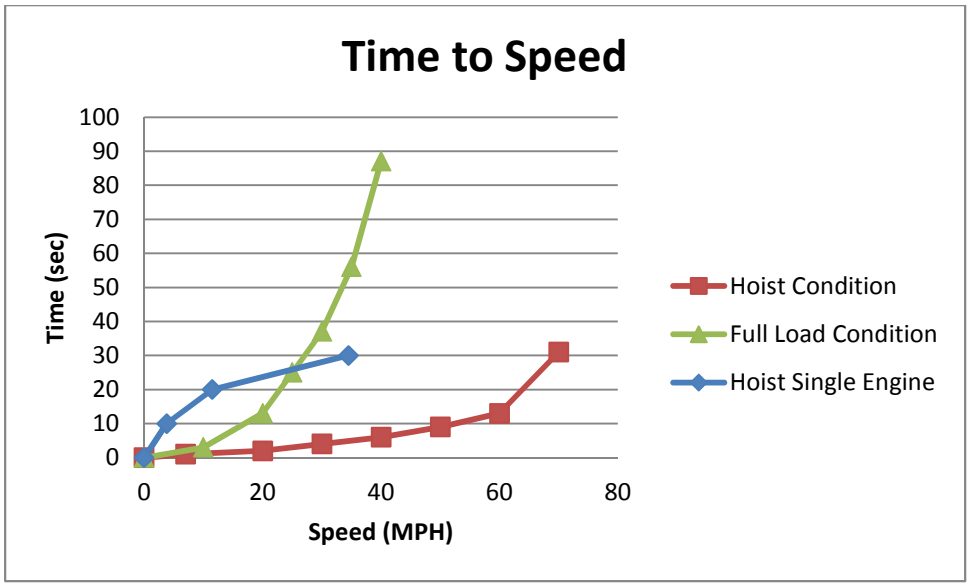
Updated metrics:


Fuel vs Speed
Fuel Rate (GPH)
30
25
20
15
10
5
0
0
20
40
60
80
Speed (MPH)
Light Condition
Hoist Condition
Full Load Condition
Hoist Single Engine


RPM vs Speed
RPM
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
Speed (MPH)
Light Condition
Hoist Condition
Full Load Condition
Hoist Single Engine


MPG vs Speed
MPG
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
Speed (MPH)
Light Condition
Hoist Condition
Full Load Condition
Hoist Single Engine


Speed vs Time
Speed (MPH)
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Time (sec)
Hoist Condition
Full Load Condition
Hoist Single Engine



Due to dusk conditions we did not have time to trial the 850B in full load with a single engine; however it seems unlikely that it would achieve the 30 knot speed requirement. We will perform this trial next time we have the craft in the fully loaded condition.

Discussion:

The boat has reasonable performance in the hoist condition with a single engine (simulated engine failure). I would expect some improvement in performance if the craft was configured for a single engine (center mounted). It seems advantageous to have the dual engine configuration. In the event of engine failure the 850B will still obtain 35 MPH in the hoist condition.

The 850B provides moderate performance in the full load condition. We are able to exceed the 30kt speed requirement by about 5kts. The added load gave the boat a more damped feel.

Indications are the DAC system is operational. Issues with GPS data have been resolved. I am collaborating with CCD as to data reduction and presentation. We will continue to upgrade and refine the DAC as we learn more.

I am in discussion now with Mercury regarding propeller selection. The goal is to find a single prop size that will perform well in both the hoist condition and full load condition.

Lightweight Shock Mitigation in Naval RIB Hull Structures Advanced Laminate Design

SCRA Subcontract #2011-510

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11M DESIGN REVIEW
November 2012

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11M Design Presentation

- 11M Drawing Package
  - Hull
  - Deck
- 11M Structural Analysis
  - Wave Load FEA (Advanced and FG variants)
  - Gun Mount FEA
  - Lift Load FEA (Advanced and FG variants)
  - Trailer Load FEA (Advanced and FG variants)
- 11M Weight Analysis
- 11M Conclusions

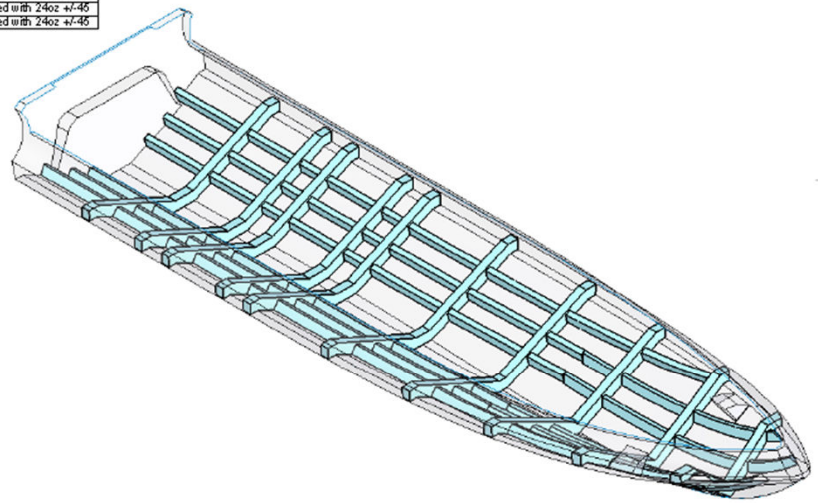
Hull Drawings- Advanced Design

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	Resin	Interplastic	CORVE8106	
3	A/R	Resin	Interplastic	CORVE8123	
4	A/R	2oz Chopped Strand Mat			
5	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
6		not used			0/90 fabric
7	A/R	E-BXM 2408 +/-45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 2308 +/-45 fabric	Vectorply	E-BXM 2308	+/-45 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	A/R	Inegra			
11	A/R	Carbon			
12	75 LF	TR4030X	Compsys	TR4030X	manufactured with 24oz +/-45
13	1	Starboard Mid Stringer	Compsys	ZDC11M-SFMS	manufactured with 24oz +/-45
14	1	Starboard Inboard Stringer	Compsys	ZDC11M-SFIS	manufactured with 24oz +/-45
15	1	Port Mid Stringer	Compsys	ZDC11M-PFMS	manufactured with 24oz +/-45
16	1	Port Inboard Stringer	Compsys	ZDC11M-PFIS	manufactured with 24oz +/-45
17		not used			
18	2 LF	TR3726X	Compsys	TR3726X	manufactured with 24oz +/-45
19	5 LF	TR6026X	Compsys	TR6026X	manufactured with 24oz +/-45
20	15 LF	TR8026X	Compsys	TR8026X	manufactured with 24oz +/-45
21	1	Bulkhead A	Compsys	ZDC11M-BH10	manufactured with 24oz +/-45
22	1	Bulkhead B	Compsys	ZDC11M-BH09	manufactured with 24oz +/-45
23	1	Bulkhead C	Compsys	ZDC11M-BH08	manufactured with 24oz +/-45
24	1	Bulkhead D	Compsys	ZDC11M-BH07	manufactured with 24oz +/-45
25	1	Bulkhead E	Compsys	ZDC11M-BH06	manufactured with 24oz +/-45
26	1	Bulkhead F	Compsys	ZDC11M-BH05	manufactured with 24oz +/-45
27	1	Bulkhead G	Compsys	ZDC11M-BH04	manufactured with 24oz +/-45
28	1	Bulkhead H	Compsys	ZDC11M-BH03	manufactured with 24oz +/-45
29	1	Bulkhead I	Compsys	ZDC11M-BH02	manufactured with 24oz +/-45
30	1	Bulkhead J	Compsys	ZDC11M-BH01	manufactured with 24oz +/-45

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

11M - HULL

DATE	6/1/2012
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 1 OF 6

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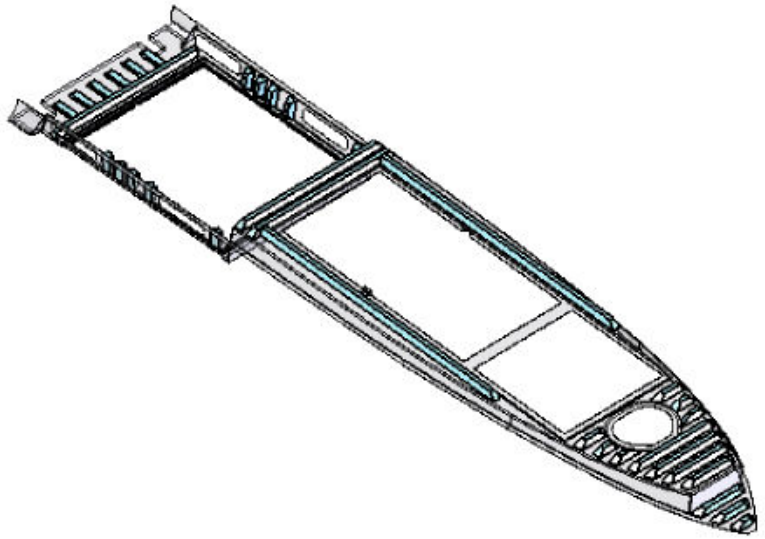
Hull Drawings- Deck Design

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2455 UB Grey	
2	A/R	Resin	Interplastic	CORVE 8106	
3		not used			
4	A/R	2oz Chopped Strand Mat			
5		not used			
6	A/R	E-BXM1208 +/- fabric	Vectorply	E-BXM 1208	+/- fabric
7	A/R	2308BX	Vectorply	2308BX	
8	A/R	E-LTM 1808 0/90 fabric	Vectorply	E-LTM-1808	0/90 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	80 LF	TR4030	Compsys	TR4030	manufactured with 24oz 0/90
11	10 LF	TR4010	Compsys	TR4010	manufactured with 24oz 0/90
12		not used			
13		not used			
14		not used			
15		not used			

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DATE	11/29/2012
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CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

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11M – Laminate Schedule Advanced Laminate

- Hull – Sharkskin 50, 2oz CSM, E BXM 2408 (in strakes only), FS2010, Innegra I BX 1200, Carbon C LT 2400, Innegra I BX 1200
  note aft keel area gets 2 x Carbon C LT 1200
- Stringers – TR4030X, 3 x E LM 1810, E BXM1208
- Bulkheads/Bulkhead Wings – Custom Preforms, 3 x E LTM 1810 (3in wide), E BXM 1208
- Deck – SK50, 2oz CSM, 2 x E LTM 1808
- Deck Framing – TR4030 (24oz 0/90), E LM 1810 uni
- Transom – SK50, 2oz CSM, 1 x E LTM 3610, Transom Preforms (24oz +/-45), bottom overlays (2 x E LM 1810), 1 x E LTM 3610

11M Advanced Laminate (AL)- FEA Load Cases

Load Case	Load ID	Description	Pressure	Load lb
1	AI	Aft Inboard, SAS	10psi	--
2	AO	Aft Outboard, SAS	10psi	--
3	AMI	Aft Mid Inboard, SAS	10psi	--
4	AMO	Aft Mid Outboard, SAS	10psi	--
5	FMI	Fwd Mid Inboard, SAS	10psi	--
6	FMO	Fwd Mid Outboard, SAS	10psi	
7	FI	Fwd, Inboard	10psi	
8	BLP	Boat Lift Points	--	105,600
9 **10**	GML GMT	Gun Mount-Longitudinal Transverse	--	*lbs *lbs
11	TLR	Trailer Analysis	--	51000

11M – FEA Advanced Design

- FEA Model of 11M Hull/Deck
- Applied Load to Hull Panels
- Deflection and Stress Reactions
- 11 Load Cases Total
  - Small Area Slamming (SAS)
  - Boat Lift Load
  - Gun Mount Load
  - Trailer Load

11M- FEA- Advanced Design

- Boat Lift Points (BLP)
- Gun Mount
  - Longitudinal (GML)
  - Transverse (GMT)
- Trailer Load Analysis (TLA)

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11M- FEA Analysis













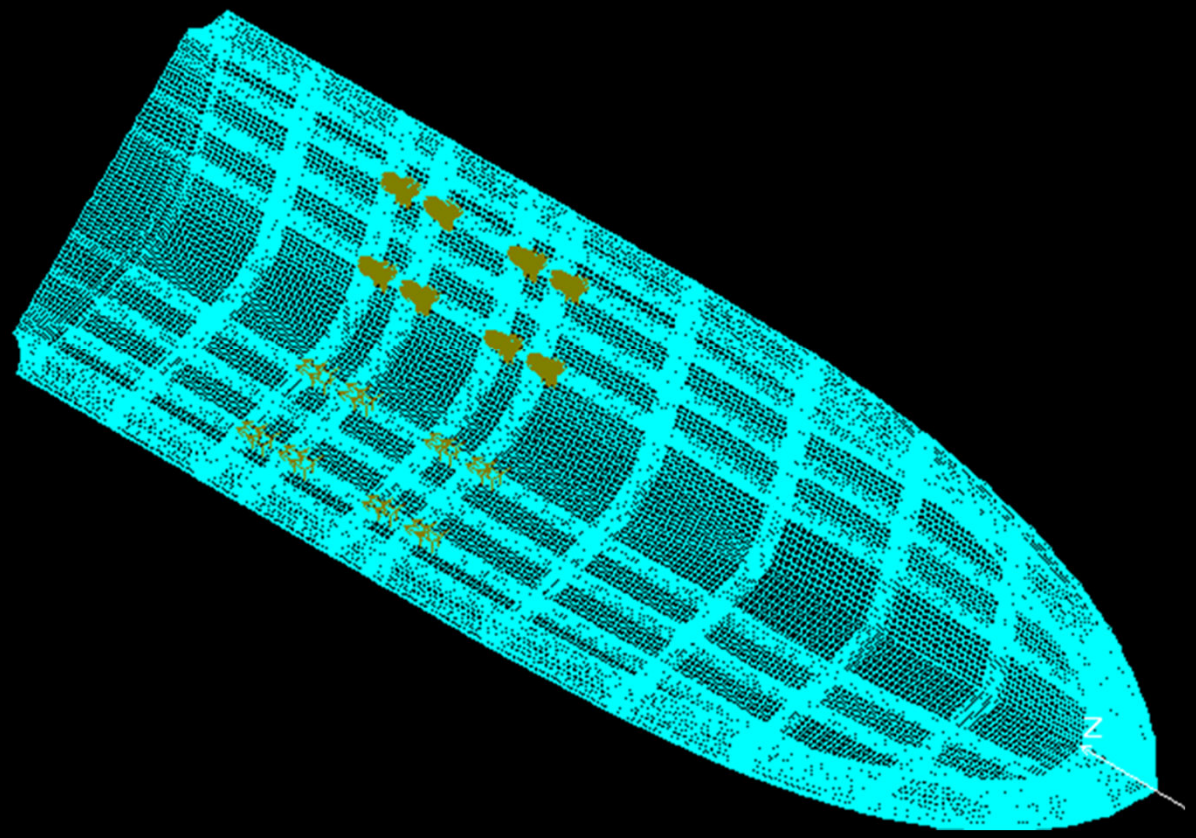








11M-AL FEA- Constraints



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11M- FEA Analysis: AL Small Area Slamming (SAS)

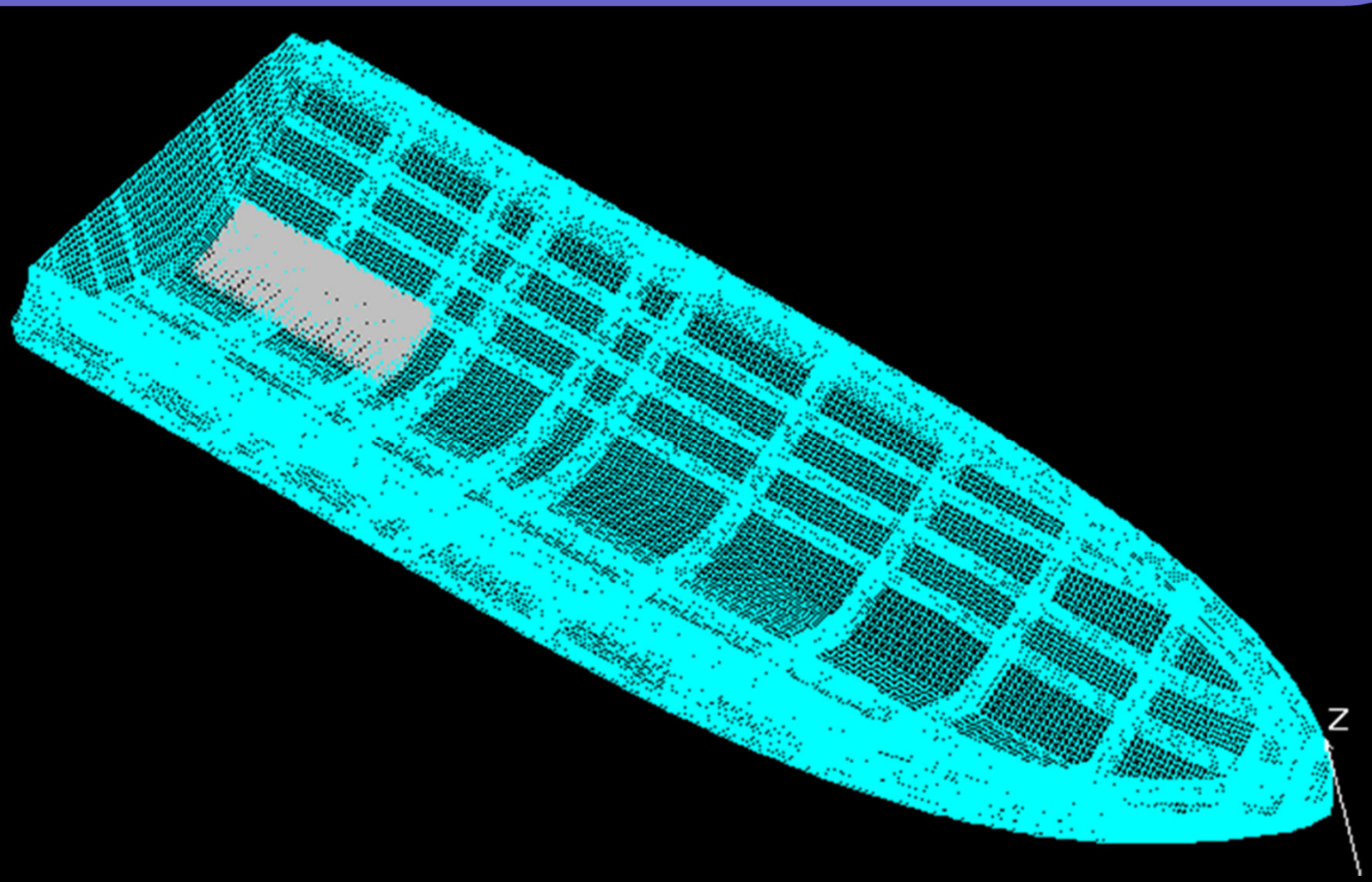


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Small Area Pressure Load AL

- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

LC1-AL- AI-10 psi Pressure Load

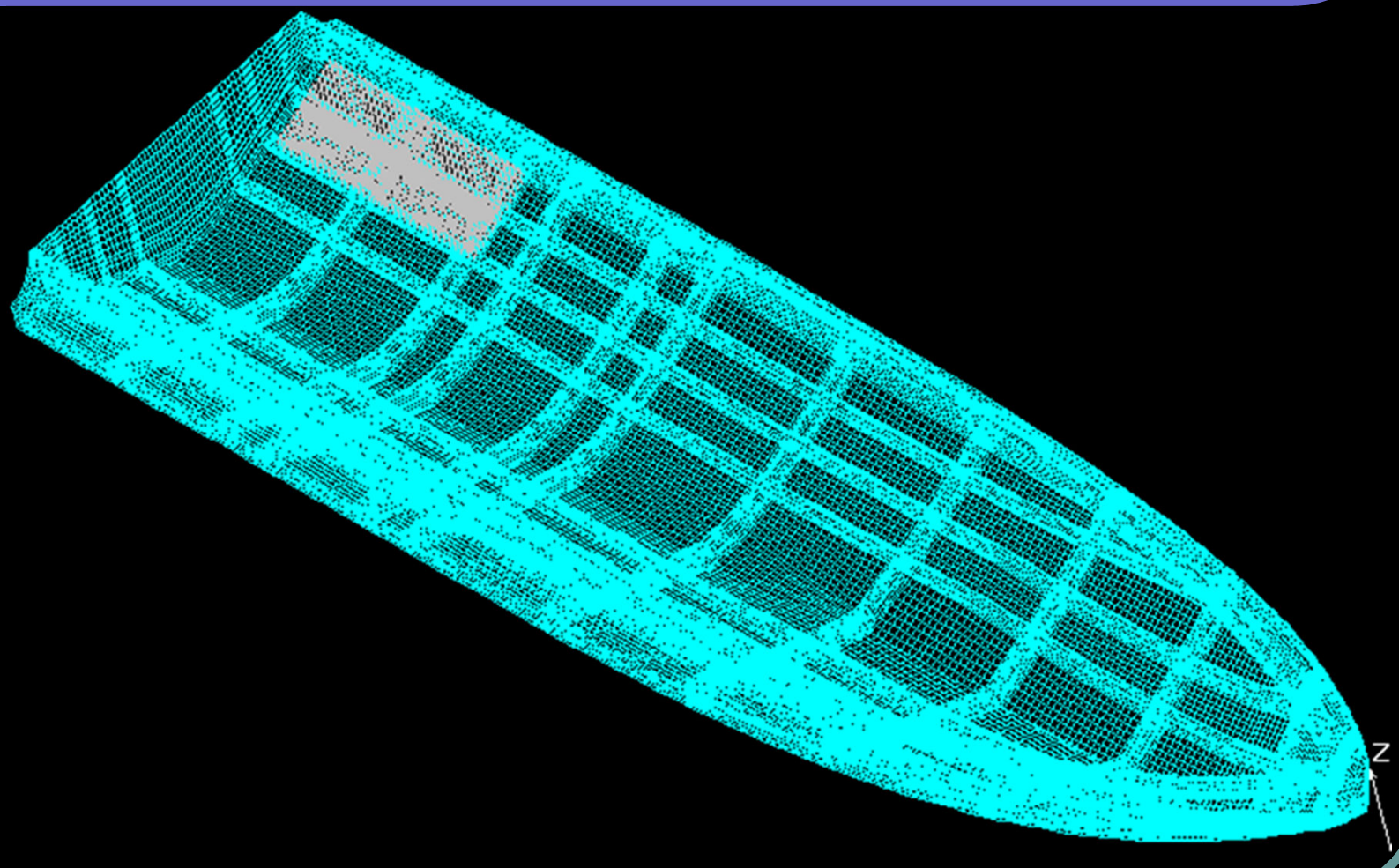


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LC1- AL- AI- Summary

- Hull range of deflection 2.24 in.
- Maximum Hull strain 0.0033 in/in
- Maximum Hull stress 24,000
- Maximum framing strain 0.0048
- Maximum framing stress 12,000 psi

LC2- AL- AO-10 psi Pressure Load



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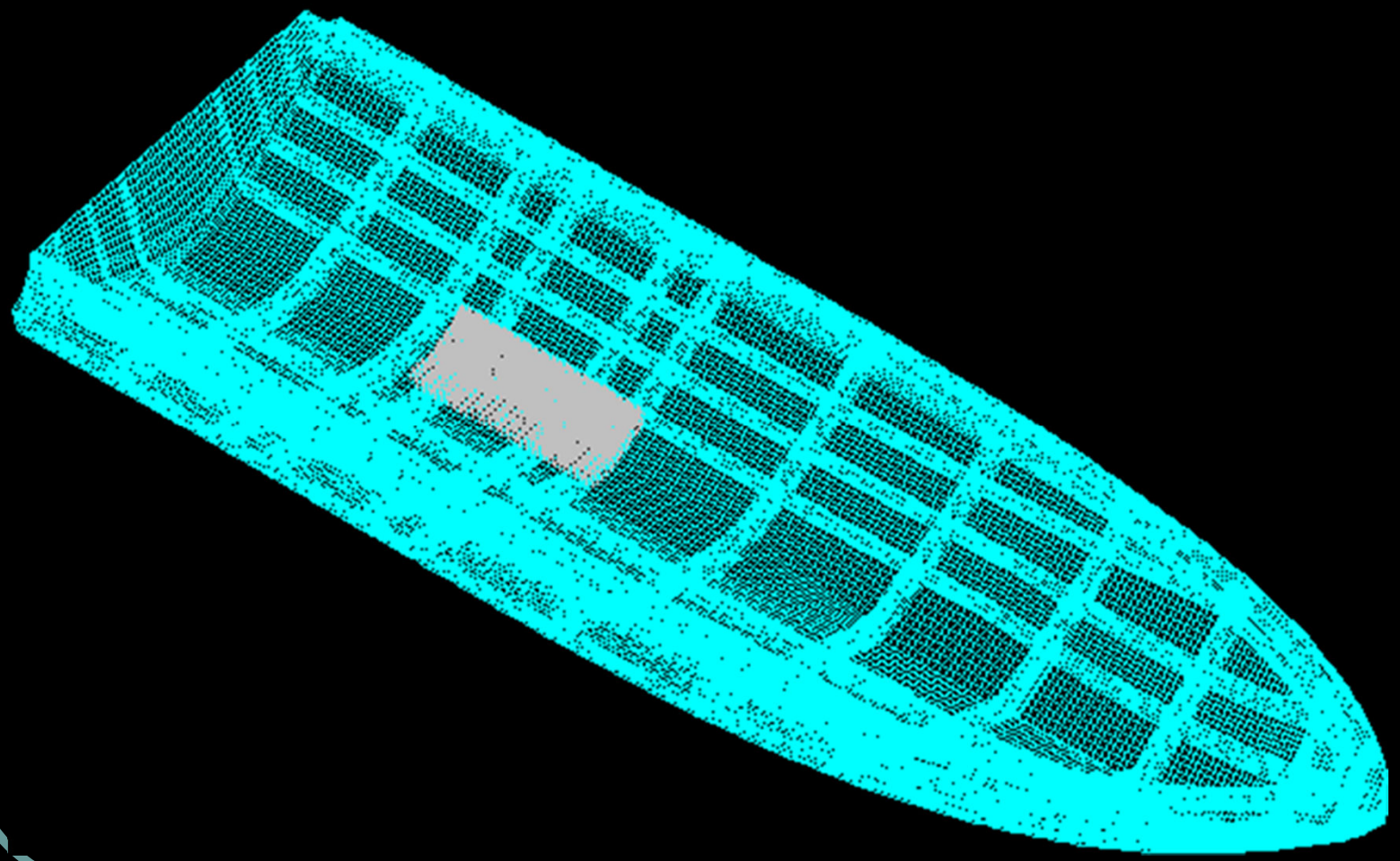
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LC2 - AL- AO- Summary

- Hull range of deflection 1.56 in
- Maximum Hull strain 0.0027 in/in
- Maximum Hull stress 20,000
- Maximum framing strain 0.0036
- Maximum framing stress 16,000 psi

LC3 - AL- AMI-10 psi Pressure Load

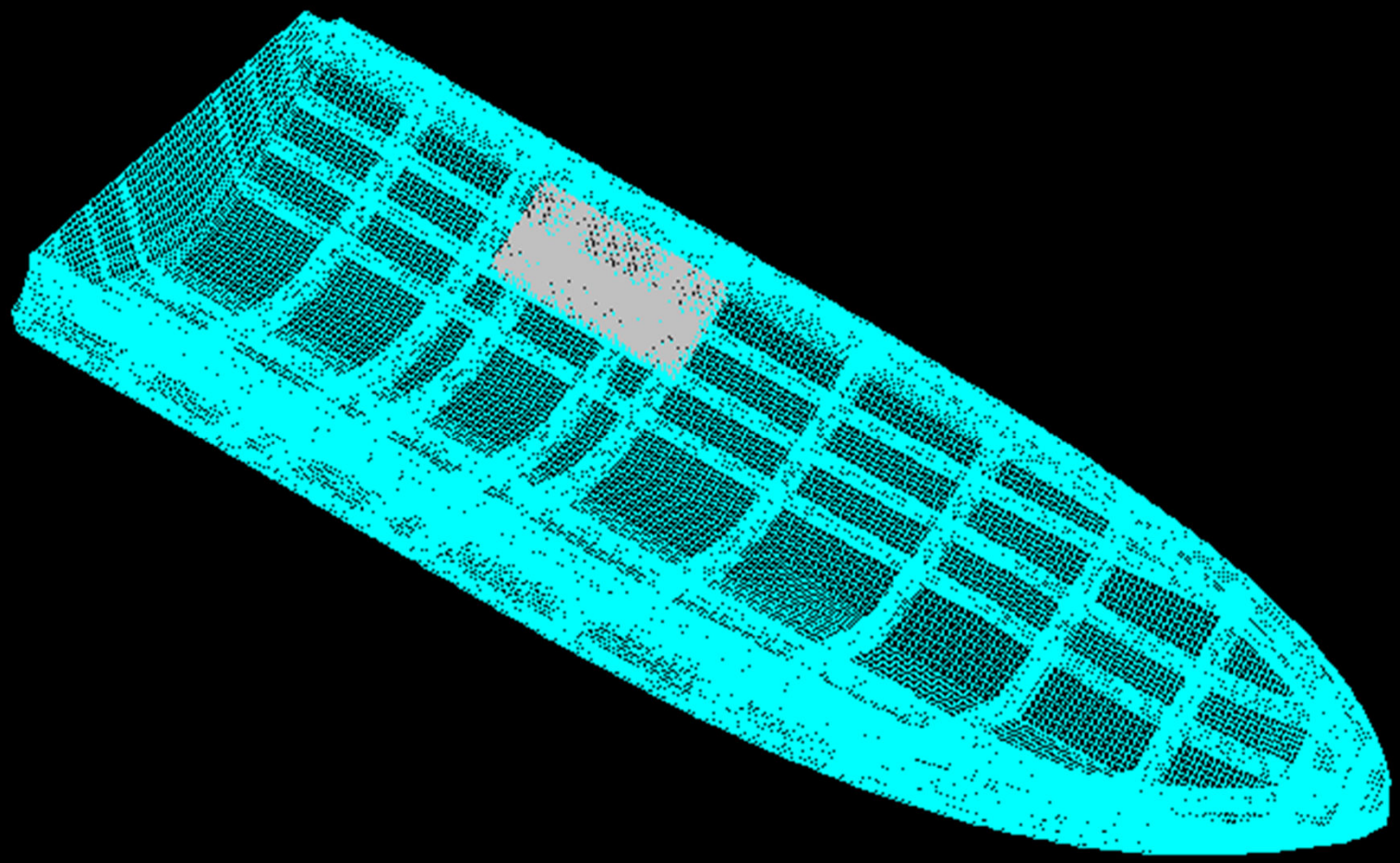


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LC3 - AL- AMI - Summary

- Hull range of deflection 0.21 in.
- Maximum Hull strain 0.0018 in/in
- Maximum Hull stress 5,500 psi
- Maximum framing strain 0.0024
- Maximum framing stress 4,000 psi

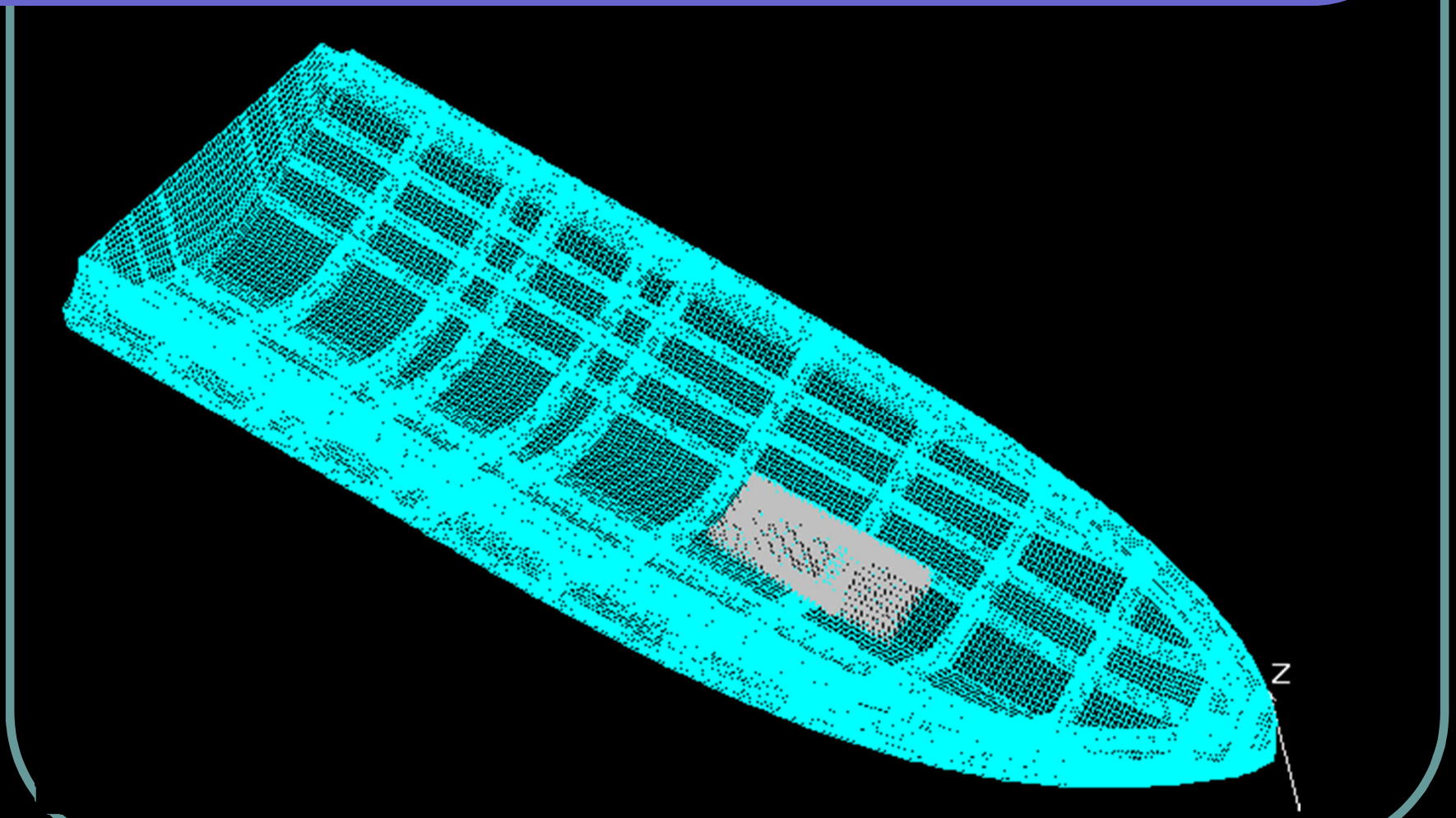
LC4 - AL- AMO -10 psi Pressure Load



LC4 - AL- AMO- Summary

- Hull range of deflection 0.28 in.
- Maximum Hull strain 0.0018 in/in
- Maximum Hull stress 12,000 psi
- Maximum framing strain 0.0003
- Maximum framing stress 5,500 psi

LC5 - AL FMI -10 psi Pressure Load

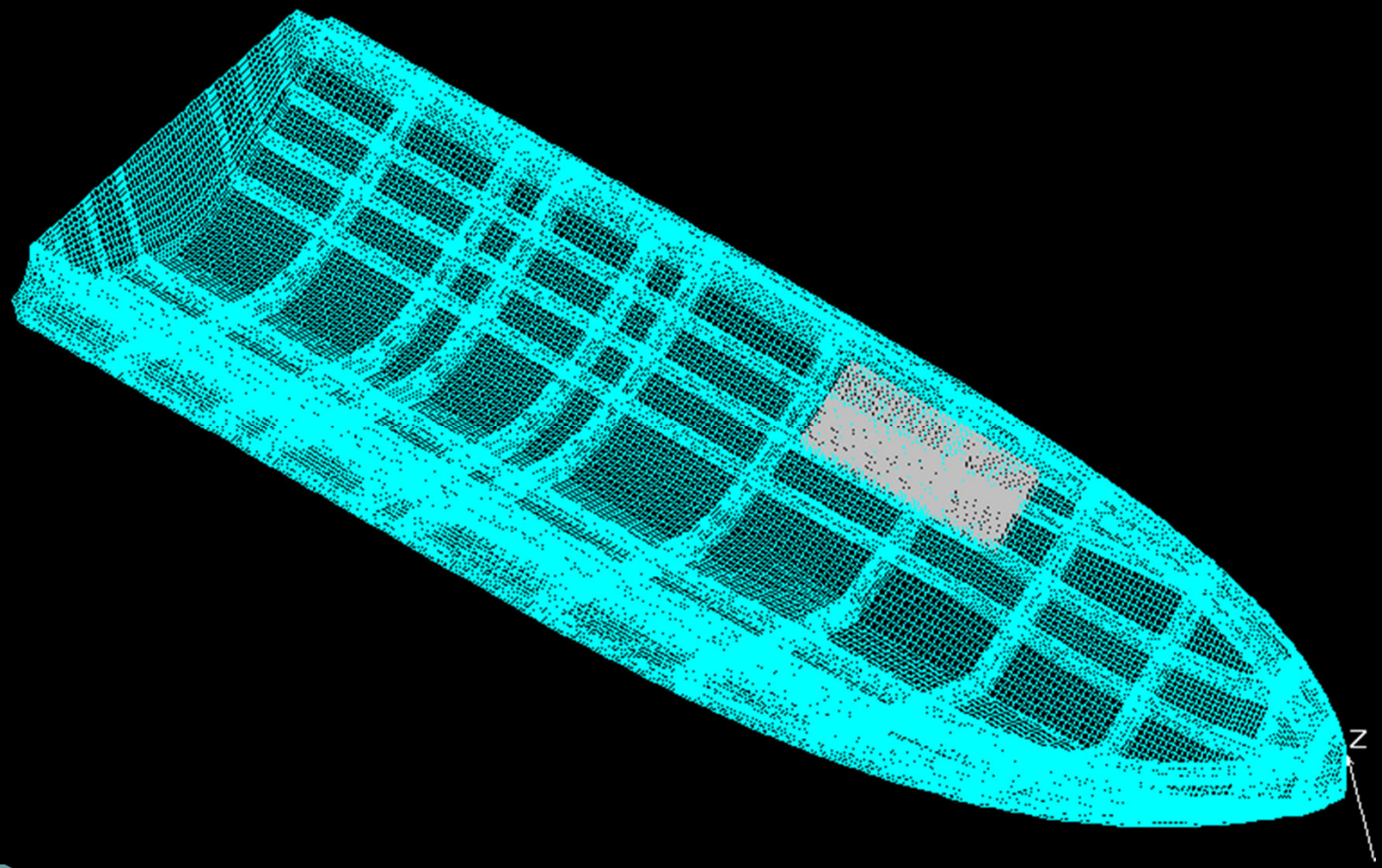


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LC5 – AL – FMO - Summary

- Hull range of deflection to 4.88 in.
- Maximum Hull strain 0.0048 in/in
- Maximum Hull stress 24,000 psi
- Maximum framing strain 0.0036 in/in
- Maximum framing stress 12,000 psi

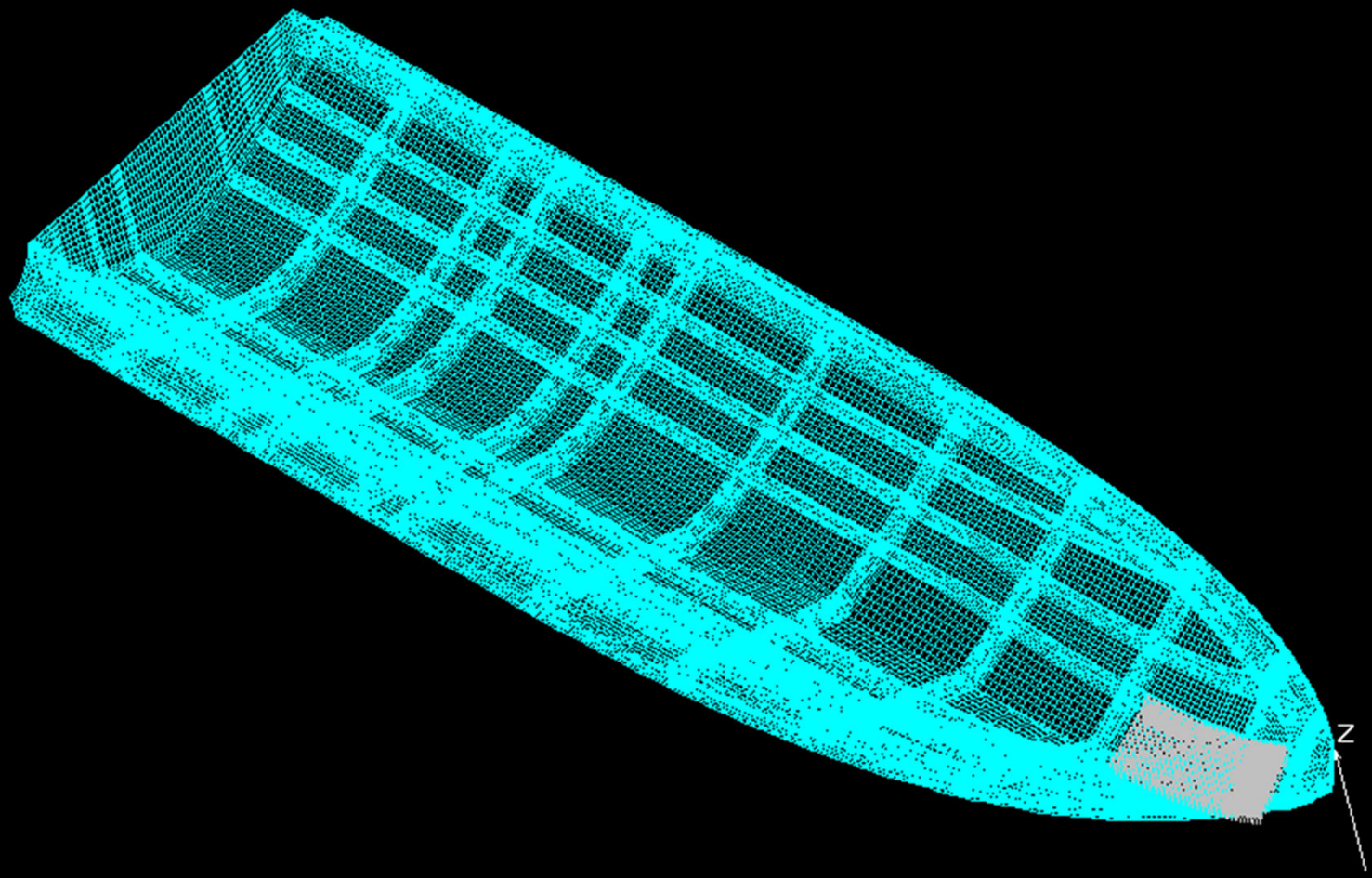
LC6 – AL - FMO-10 psi Pressure Load



LC6 – AL – FMO - Summary

- Hull range of deflection 4.49 in.
- Maximum Hull strain 0.003 in/in
- Maximum Hull stress 24,000 psi
- Maximum framing strain 0.0036 in/in
- Maximum framing stress 19,000 psi

LC7 – AL – FI - 10 psi Pressure Load



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LC7 – AL – FI - Summary

- Hull range of deflection to 12.02 in.
- Maximum Hull strain 0.0036 in/in
- Maximum Hull stress 24,000 psi
- Maximum framing 0.0033 strain
- Maximum framing stress 12,000 psi

LC(1-7) - AL - SAS Summary

Range of maximum values in SAS cases

- Hull range of deflection 0.21 to 12.02 in.
- Maximum Hull strain 0.0048 in/in
- Maximum Hull stress 24,000 psi
- Maximum Frame strain 0.0048 in/in
- Max framing stress to 19,000 psi

11M- FEA Analysis: Boat Lifting Points (B.L.P.)



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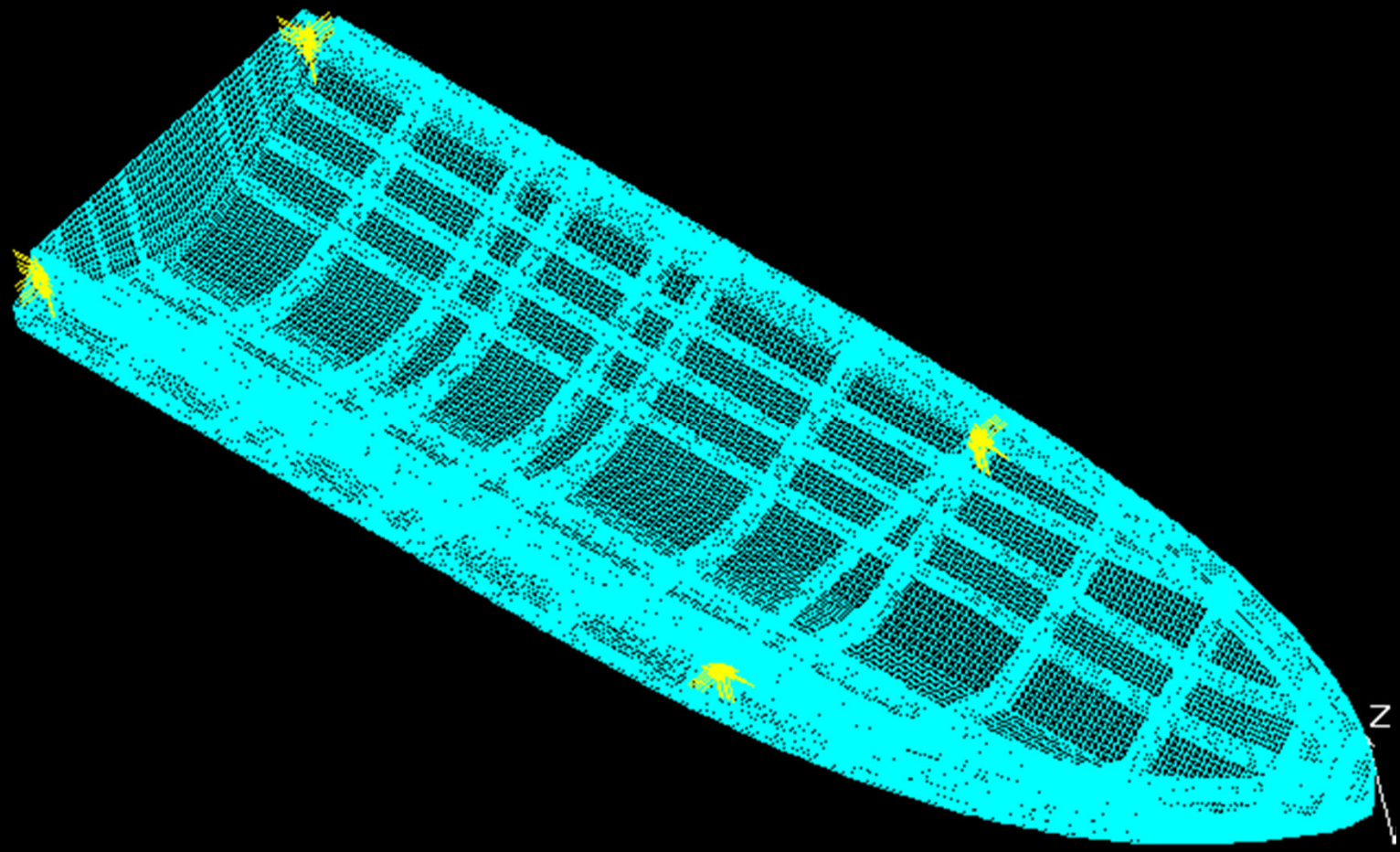
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
- 55,490 lbs at engine mounts (from constraints)
- -50,110 lbs distributed load (-1 lb at each of 50,110 nodes)
- Total weight 105,600 lbs (6 x 17,600 lbs

LC8- BLP- Load Data

- Vertical loads
  - 26,400 lbs at each point
  - 105,600 lbs total (6 x 17,600 lbs)
- Transverse loads
  - -1056 lbs stbd side lift points
  - 1056 lbs port side lift points
- Longitudinal loads
  - 13,200 lbs at aft points
  - -13,200 lbs at fwd points

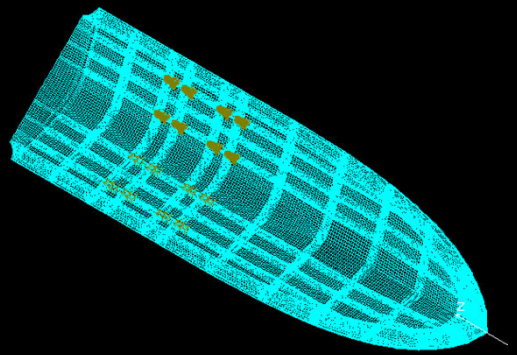
LC8-AL- BLP- Force Vector at Lift Points



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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints F_r < 1 lb
- Thus constraints do not affect results



LC8-AL- BLP- Lift Analysis Summary

- Hull range of deflection -3.0 to 2.7 in.
- Maximum strain 0.02 in/in
- Maximum long stress 48,000 psi
- Maximum Transverse stress 70,000 psi
- Maximum 45 axis stress 80,000

11M- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

34

LC9/LC10-Gun Mount Framing Notes

- This is a stiffness design, thus stresses are low
- Four transverse frames, TR2030X, are placed on 3.5 in centers
- Skin laminate is 4 layers of 3610 (entire foredeck, including tube support areas)
- Frame laminate
  - 24 oz (+/-45) on PRISMA beam
  - 4 layers 4” wide 1810 warp uni on frame caps
  - 2408 (+/-45) cover fabric (overlapping adjacent tabs)

LC9- GML- Long. Loading

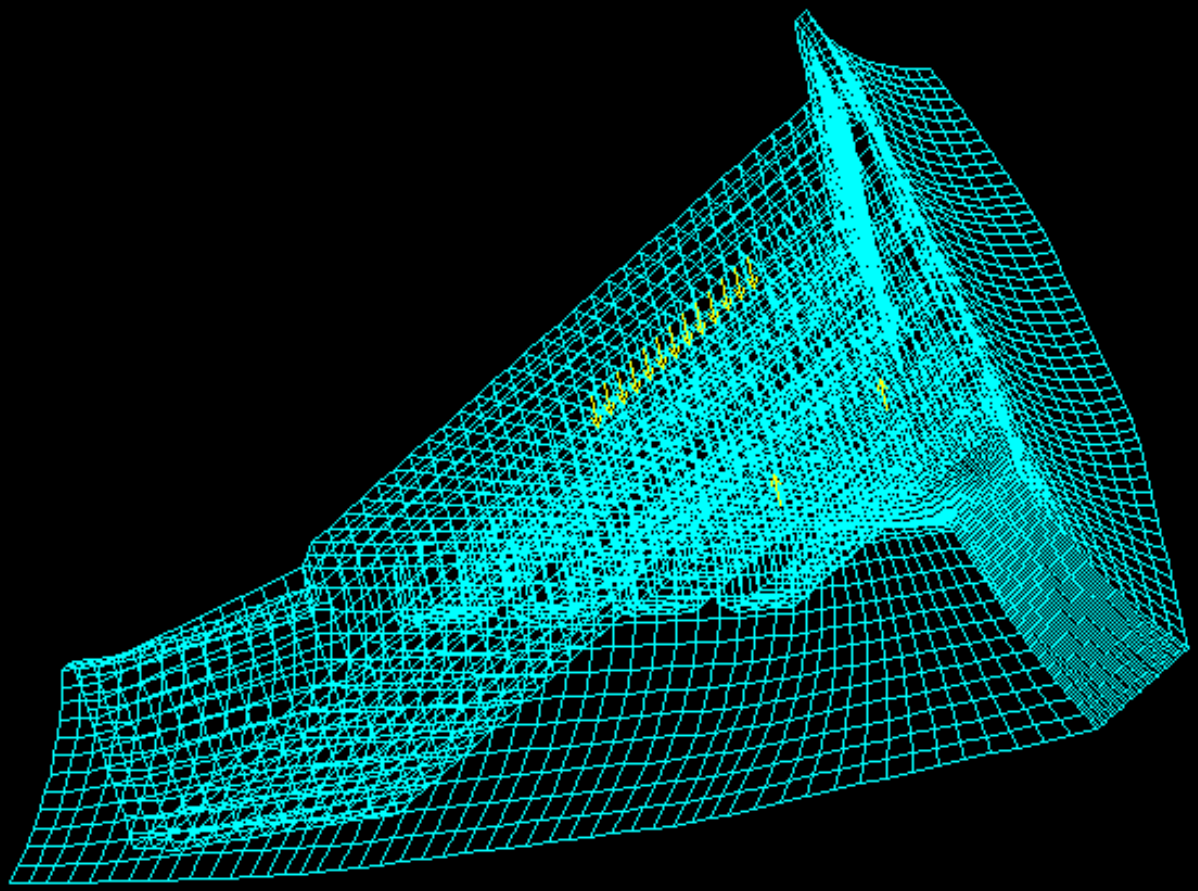
Forward

- Two bolts
- Tensile loading 2250 lbs each bolt

Aft

- Loading at 13 nodes along aft edge of mounting plate
- Compressive loading 347 lbs each point

LC9- GML- Long. Loading

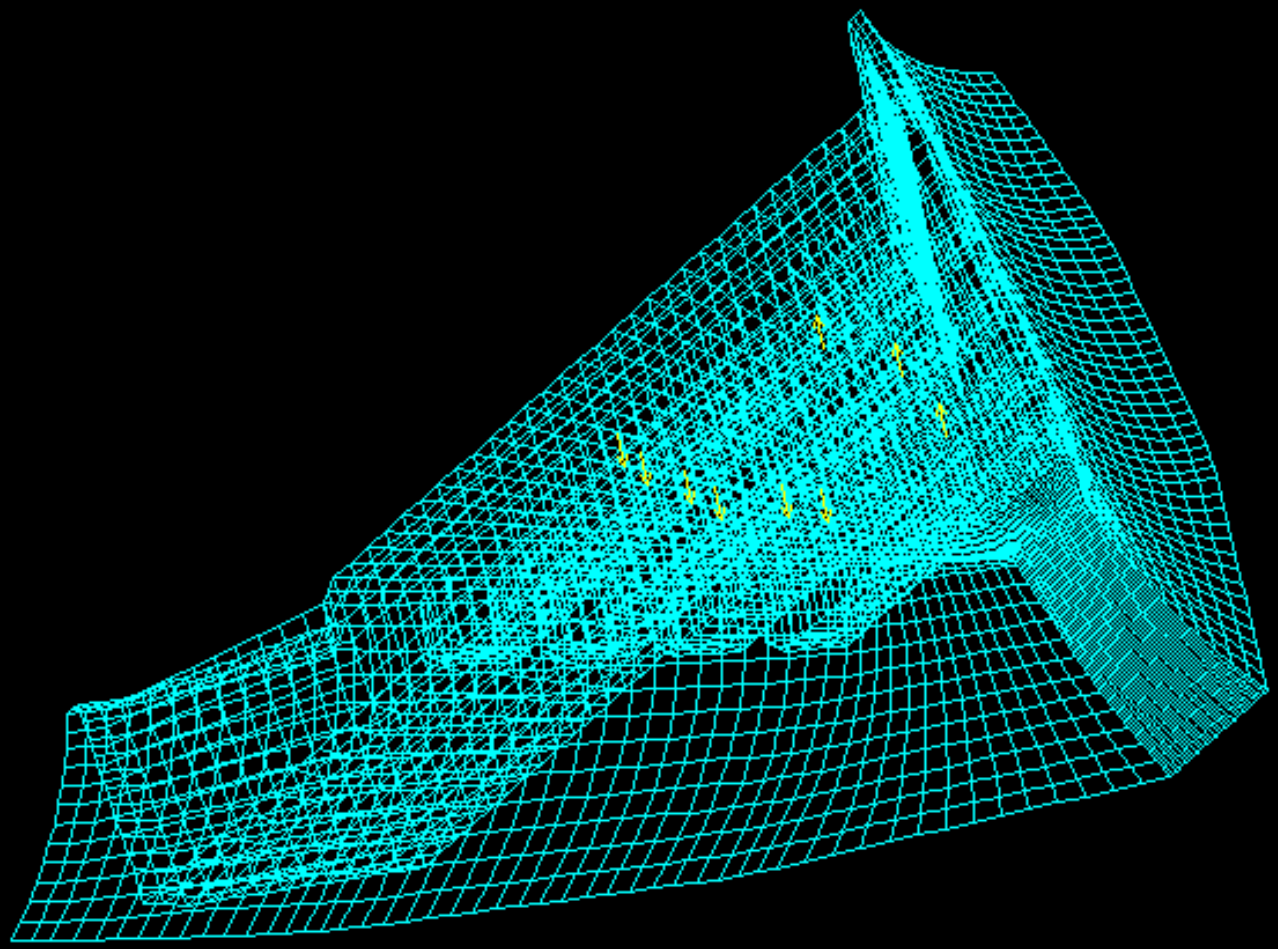


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LC9-11M- G.M.L- Summary

- Range of deflection -.14 to .11 in.
- Maximum strain 0.004 in./in.
- Maximum longitudinal stress 12,000 psi
- Maximum transverse stress 12,000 psi

LC10- GMT- Trans. Loading



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LC10- G.M.T- Summary

- Range of deflection -.25 to .18 in.
- Maximum strain 0.004 in./in.
- Maximum longitudinal stress 6,000 psi
- Maximum transverse stress 8,000 psi

LC9 and LC10 Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
- FOS for strength in excess of 10

11M- FEA Analysis: Trailer Load Analysis (TLA)

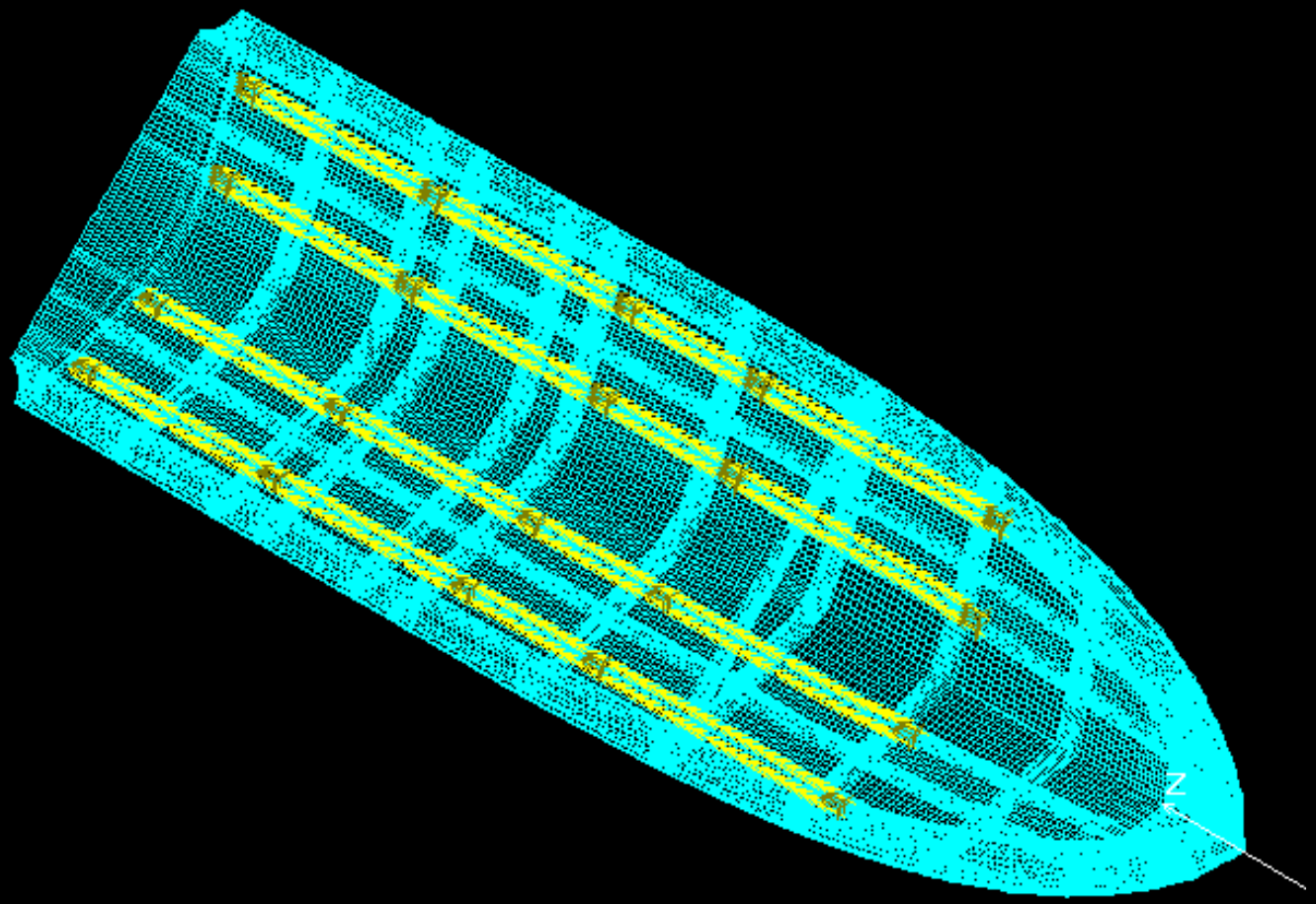


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LC11-AL Trailer Loads Applied

- 3G vertical acceleration (51,000 lbs)
- Weight is uniformly distributed over boat (-1.06 lbs on each node = -51,000 lbs
- Boat is supported by 4 bunks, located under inner and outer stringers on each side
- Bunk support modeled as vertical force applied along bottom side of stringer frames (50 lbs on each of 1008 nodes for 50,400 lbs)
- Bunk supports modeled s vertical constraints (600 lbs total reaction)

LC11-AL Trailer Loads- Bunk and Loading Constraints



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11M-AL LC11- TLA Summary

- Range of deflection to -2.5 in to .13 in.
- Maximum hull strain 0.004 in/in
- Maximum framing stress 15,000 psi

Weight Evaluation AL Advanced Laminate

Component	Weight (lb)
Hull	930-960
Deck	470-490

Total Weight Hull and Deck - Advanced Hull Laminate	**1400-1450 55% to 57% Savings from Baseline**

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 11M- Exceeds Metrics, On Target

Weight Evaluation Advanced and FG

Component	AL- Weight(lb)	FG-Weight (lb)
Hull	930-960	1070-1100
Deck	470-490	470-490

Total Weight Hull and Deck	**1400-1450 55% to 57% Savings from Baseline**	**1540-1590 50 to 53% Savings from Baseline**

11M Conclusions

- Both Advanced and Fiberglass designs are adequate
- Both Designs Exceed Weight Reduction Goal
- Fiberglass Design chosen for Rapid Implementation- Lower Risk
- Advanced Design recommended if Navy Desires to advance new materials- Higher Risk

11M- Extended Drawings and FEA Analysis Slides



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11M- Drawings Package



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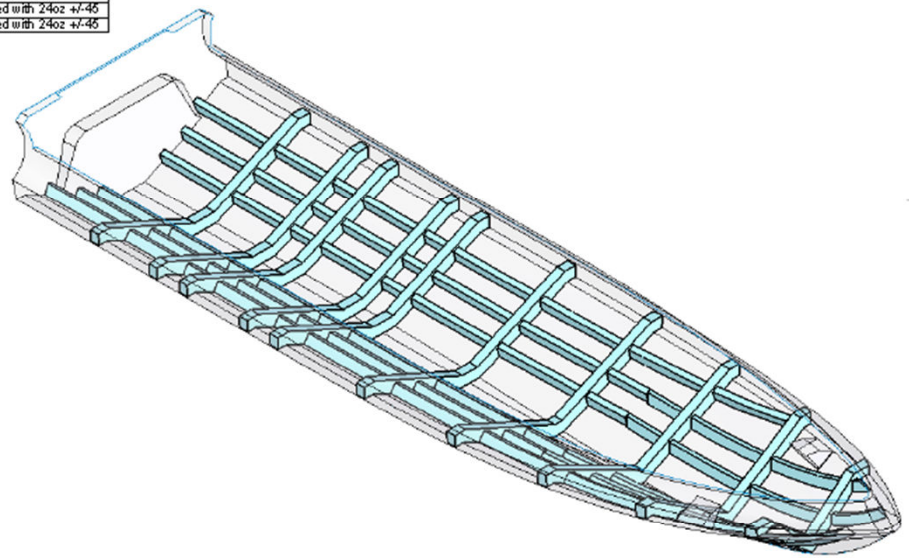
Hull Drawings- Advanced Design

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	Resin	Interplastic	CORVE 8106	
3	A/R	Resin	Interplastic	CORVE 8123	
4	A/R	2oz Chopped Strand Mat			
5	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
6		not used			0/90 fabric
7	A/R	E-BXM 2408 +/-45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 2308 +/-45 fabric	Vectorply	E-BXM 2308	+/-45 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	A/R	Inegra			
11	A/R	Carbon			
12	75 LF	TR4030X	Compsys	TR4030X	manufactured with 24oz +/-45
13	1	Starboard Mid Stringer	Compsys	ZDC11M-SFMS	manufactured with 24oz +/-45
14	1	Starboard Inboard Stringer	Compsys	ZDC11M-SFIS	manufactured with 24oz +/-45
15	1	Port Mid Stringer	Compsys	ZDC11M-PFMS	manufactured with 24oz +/-45
16	1	Port Inboard Stringer	Compsys	ZDC11M-PFIS	manufactured with 24oz +/-45
17		not used			
18	2 LF	TR3726X	Compsys	TR3726X	manufactured with 24oz +/-45
19	5 LF	TR6026X	Compsys	TR6026X	manufactured with 24oz +/-45
20	15 LF	TR8026X	Compsys	TR8026X	manufactured with 24oz +/-45
21	1	Bulkhead A	Compsys	ZDC11M-BH10	manufactured with 24oz +/-45
22	1	Bulkhead B	Compsys	ZDC11M-BH09	manufactured with 24oz +/-45
23	1	Bulkhead C	Compsys	ZDC11M-BH08	manufactured with 24oz +/-45
24	1	Bulkhead D	Compsys	ZDC11M-BH07	manufactured with 24oz +/-45
25	1	Bulkhead E	Compsys	ZDC11M-BH06	manufactured with 24oz +/-45
26	1	Bulkhead F	Compsys	ZDC11M-BH05	manufactured with 24oz +/-45
27	1	Bulkhead G	Compsys	ZDC11M-BH04	manufactured with 24oz +/-45
28	1	Bulkhead H	Compsys	ZDC11M-BH03	manufactured with 24oz +/-45
29	1	Bulkhead I	Compsys	ZDC11M-BH02	manufactured with 24oz +/-45
30	1	Bulkhead J	Compsys	ZDC11M-BH01	manufactured with 24oz +/-45

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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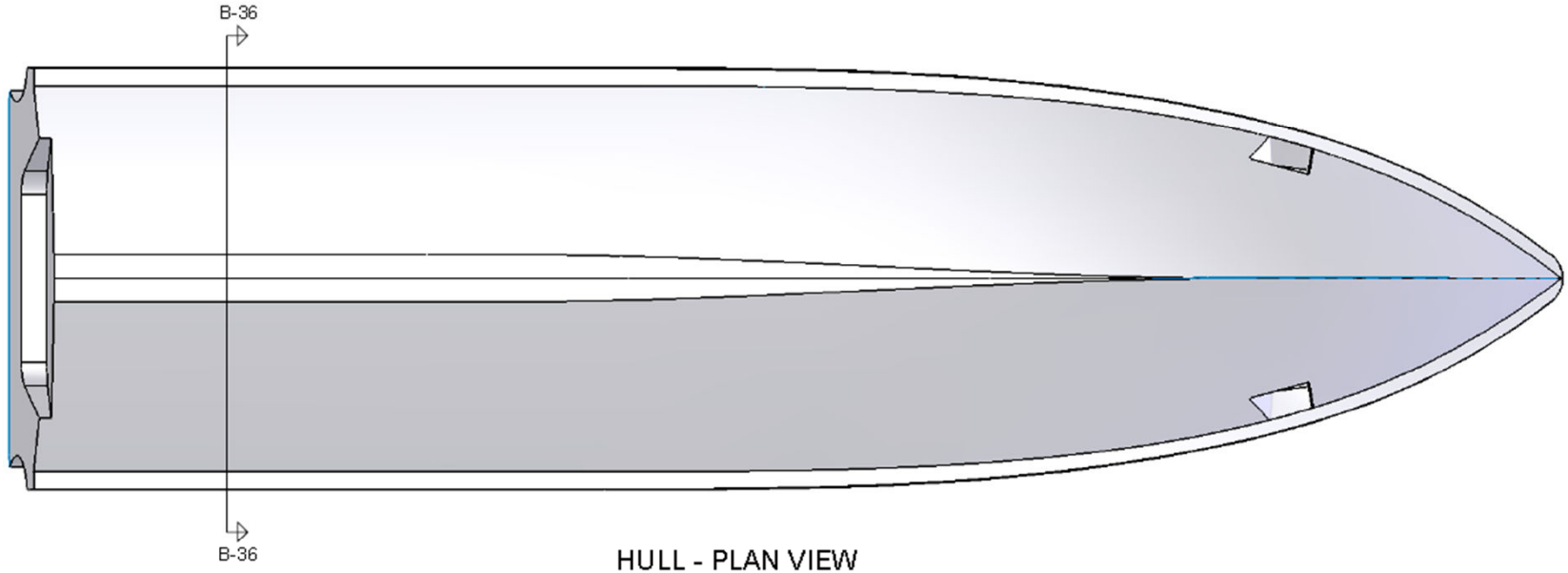
11M - HULL

DATE	6/1/2012
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 1 OF 6

Hull Drawings- Advanced Design

LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
4	2oz Chopped Strand Mat	
7	E-BXM 2408 +/- 45 fabric (k strakes only)	see detail E-10
29	PS2010	
5	E LTM 3610 D90 fabric	overlap k keel
5	E LTM 3610 D90 fabric	overlap k keel
10	Integra	k keel and chine flat
11	Carbon	k keel and chine flat
11	Carbon	k keel
10	Integra	k keel and chine flat



HULL - PLAN VIEW
LOOKING DOWN

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11M - HULL

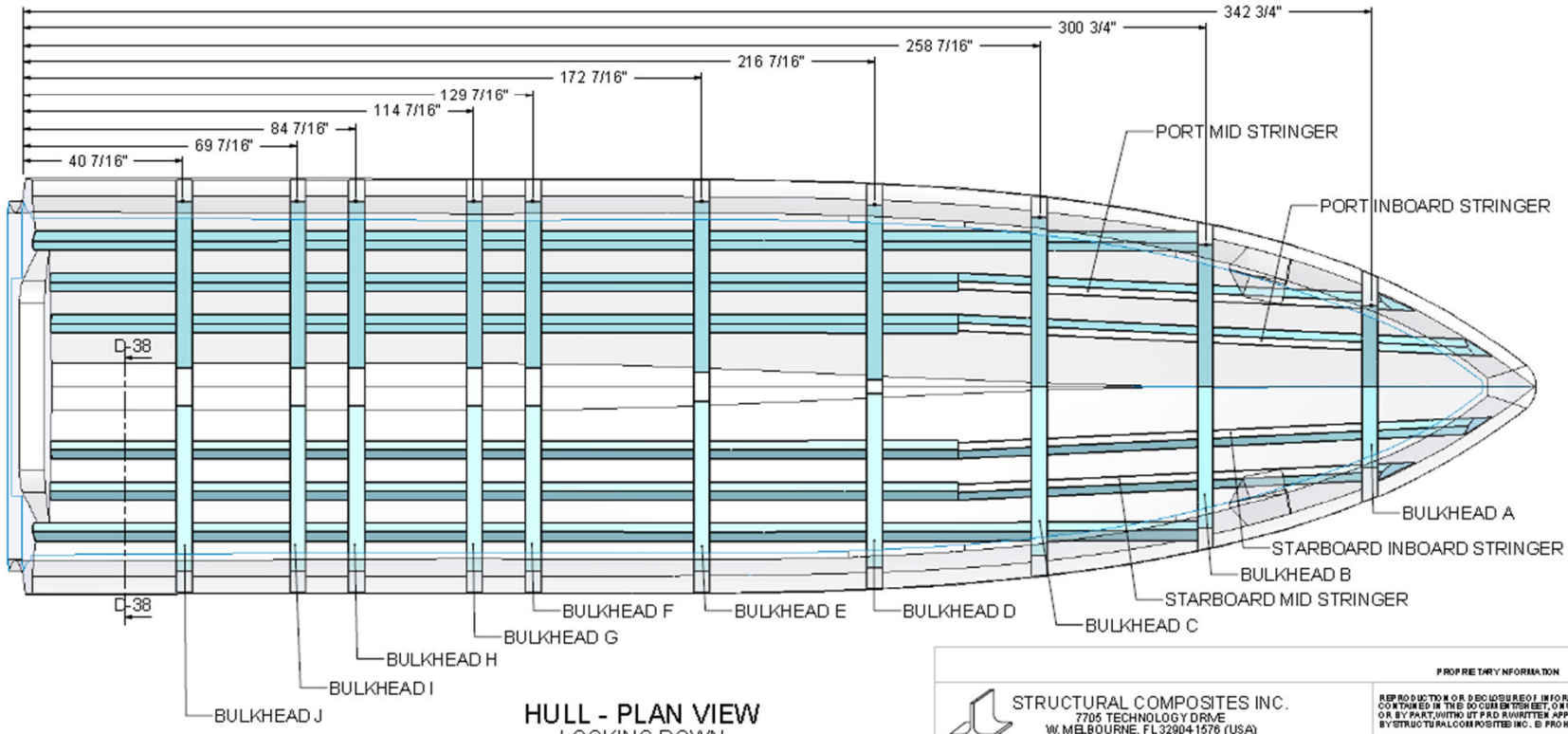
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CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 2 OF 6

Hull Drawings- Advanced Design

LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
12	TR4030X	manufactured with 24oz +/-45
13	Starboard Mid Stringer	manufactured with 24oz +/-45
14	Starboard Inboard Stringer	manufactured with 24oz +/-45
15	Port Mid Stringer	manufactured with 24oz +/-45
16	Port Inboard Stringer	manufactured with 24oz +/-45
21	Bulkhead A	manufactured with 24oz +/-45
22	Bulkhead B	manufactured with 24oz +/-45
23	Bulkhead C	manufactured with 24oz +/-45
24	Bulkhead D	manufactured with 24oz +/-45
25	Bulkhead E	manufactured with 24oz +/-45
26	Bulkhead F	manufactured with 24oz +/-45
27	Bulkhead G	manufactured with 24oz +/-45
28	Bulkhead H	manufactured with 24oz +/-45
29	Bulkhead I	manufactured with 24oz +/-45
30	Bulkhead J	manufactured with 24oz +/-45
9	E-LM 1810 0 fabric	
9	E-LM 1810 0 fabric	
9	E-LM 1810 0 fabric	
8	E-BXM 2308 +/-45 fabric	



HULL - PLAN VIEW
LOOKING DOWN

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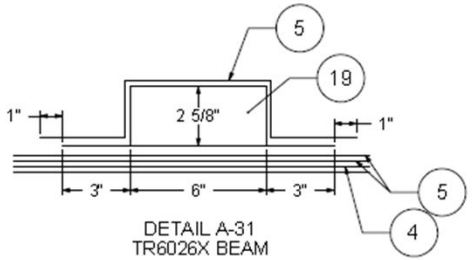
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DATE	6/1/2012
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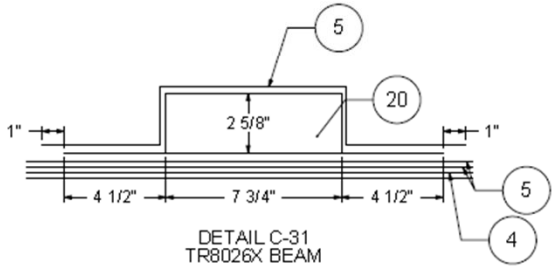
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Hull Drawings- Advanced Design

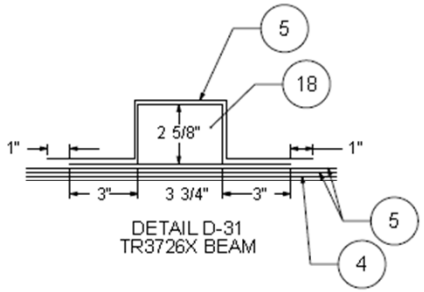
LAMINATE SCHEDULE		
ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
4	2oz Chopped Strand Mat	
5	E LTM 3610 0/90 fabric	
5	E LTM 3610 0/90 fabric	
18	TR3726X	
19	TR6026X	
20	TR8026X	
5	E-LTM 3610 0/90 fabric	cut at 45°
25	Starboard transom knee	
26	Port Transom Knee	



DETAIL A-31
TR6026X BEAM



DETAIL C-31
TR8026X BEAM



DETAIL D-31
TR3726X BEAM

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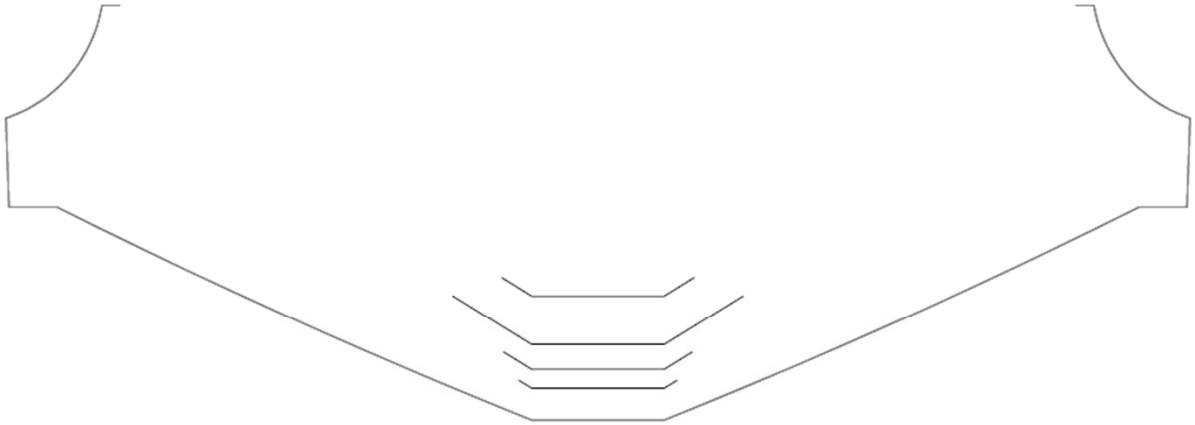
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11MA HULL

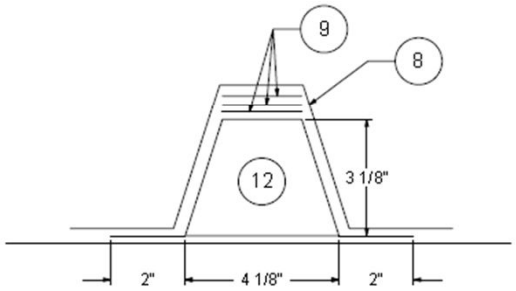
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DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11MA-1 | SHEET 1 OF 6

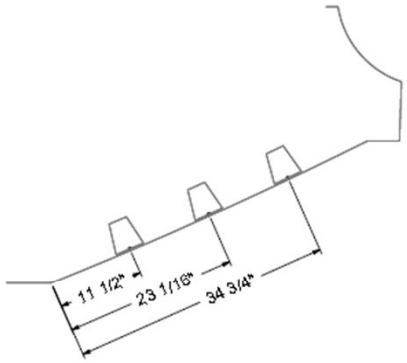
Hull Drawings- Advanced Design



SECTION B-36



DETAIL E-34
LONGITUDINAL TR4030X
TYPICAL FRAMING DETAIL



SECTION D-38

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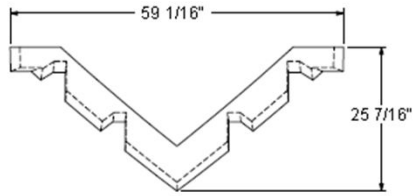
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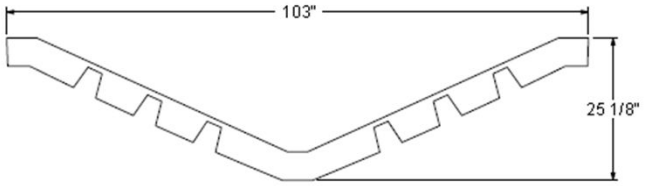
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DRAWN	TEB BALTAZAR
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APRVD	XXXXXXXXXX
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SCALE: NTS | JOB No. | DWG No. XXXX-11MA-1 | SHEET 5 OF 6

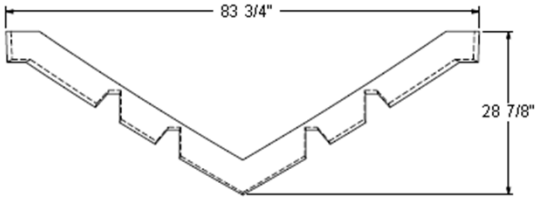
Hull Drawings- Advanced Design



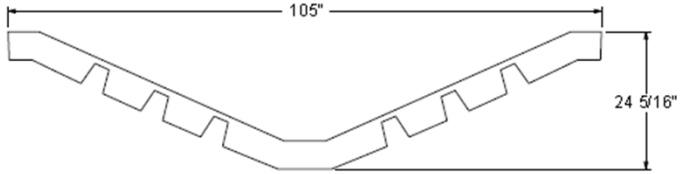
DETAIL B-42
BULKHEAD A



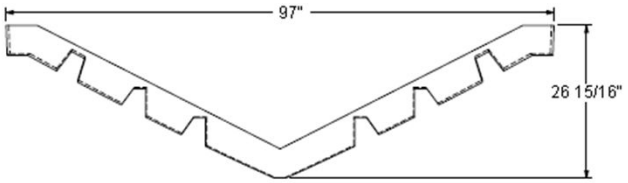
DETAIL B-46
BULKHEAD D



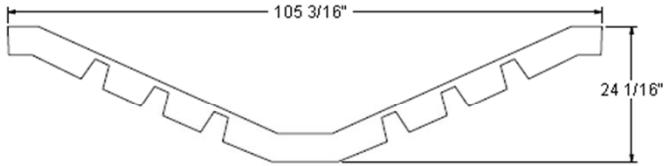
DETAIL D-42
BULKHEAD B



DETAIL C-46
BULKHEAD E



DETAIL E-42
BULKHEAD C



DETAIL E-46
BULKHEAD F,G,H,I,J

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DRAWING TITLE

11MA HULL

DATE	6/1/2012
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11MA-1 | SHEET 6 OF 6

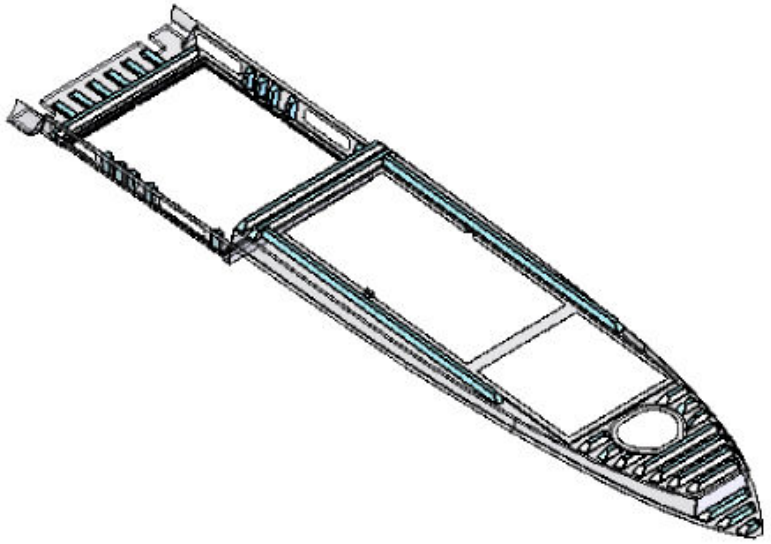
11M- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	Resin	Interplastic	CORVE 8106	
3		not used			
4	A/R	2oz Chopped Strand Mat			
5		not used			
6	A/R	E-BXM1208 +/- fabric	Vectorply	E-BXM 1208	+/- fabric
7	A/R	2308BX	Vectorply	2308BX	
8	A/R	E-LTM 1808 0/90 fabric	Vectorply	E-LTM-1808	0/90 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	80 LF	TR4030	Compsys	TR4030	manufactured with 24oz 0/90
11	10 LF	TR4010	Compsys	TR4010	manufactured with 24oz 0/90
12		not used			
13		not used			
14		not used			
15		not used			

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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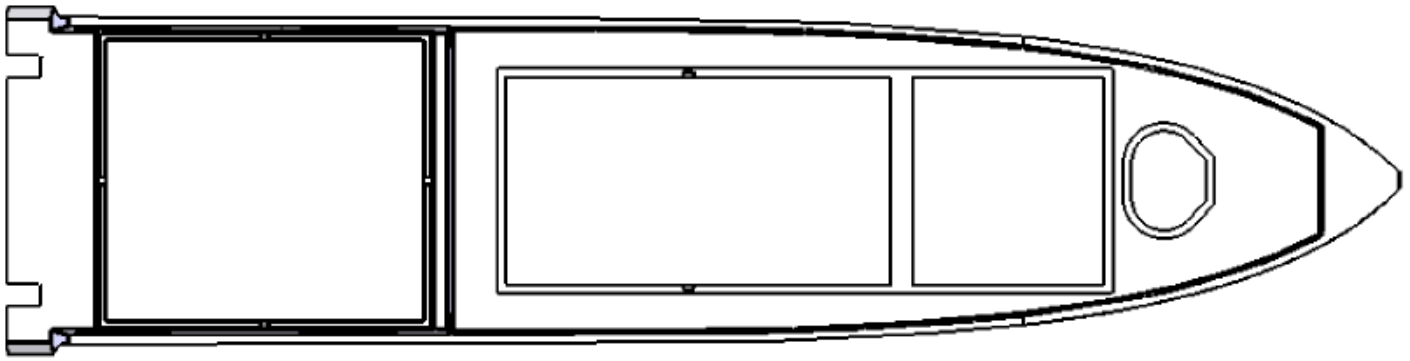
11M - DECK

DATE	11/30/2012
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 1 OF 3

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11M- Deck Drawings



DECK - PLAN VIEW
LOOKING UP

PROPRIETARY INFORMATION

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11M - DECK

DATE	11/29/2012
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXX
APPVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-2 | SHEET 2 OF 3

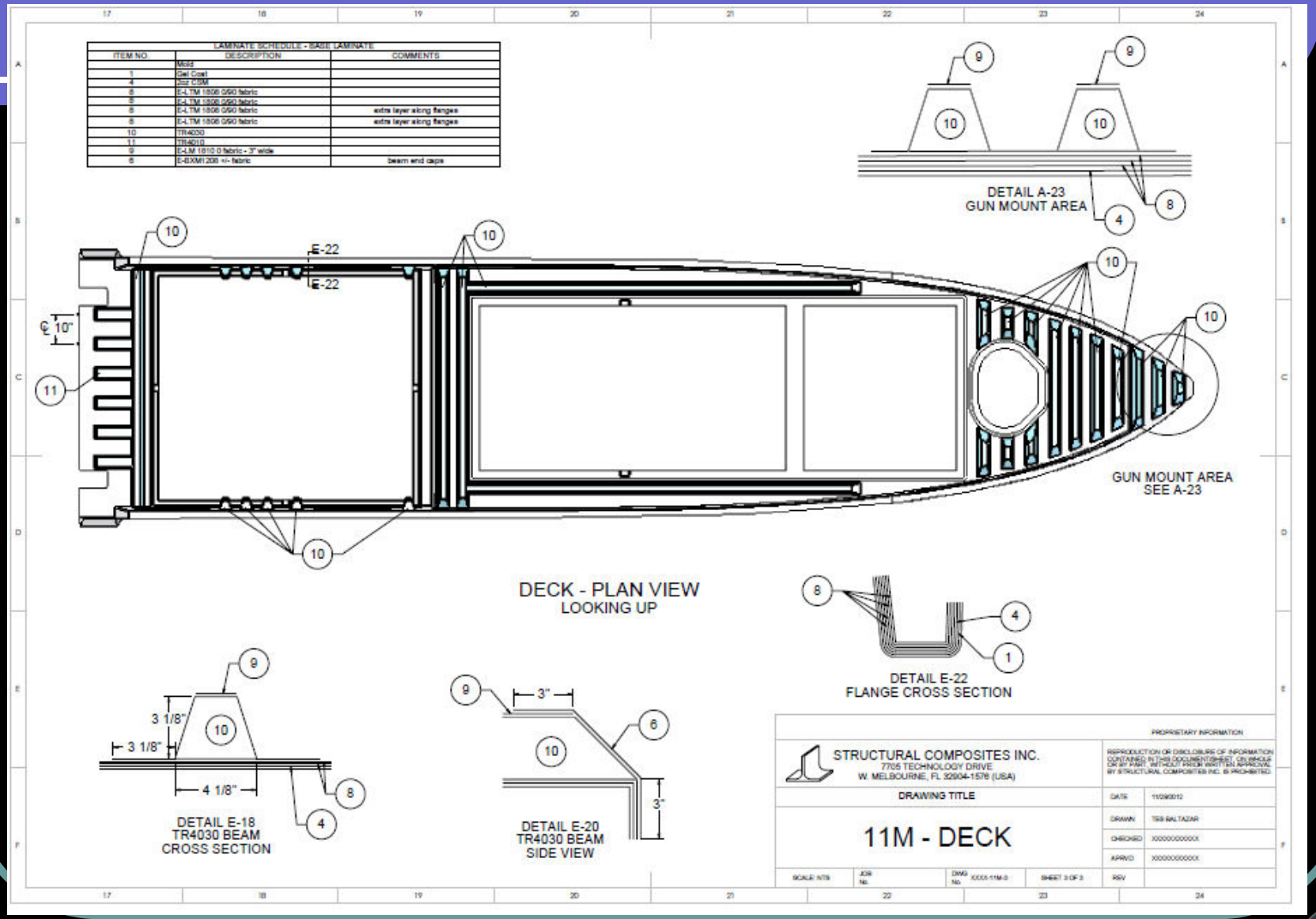
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11M- Deck Drawings



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11M – Laminate Schedule Advanced Laminate

- Hull – Sharkskin 50, 2oz CSM, E BXM 2408 (in strakes only), FS2010, Innegra I BX 1200, Carbon C LT 2400, Innegra I BX 1200
  note aft keel area gets 2 x Carbon C LT 1200
- Stringers – TR4030X, 3 x E LM 1810, E BXM1208
- Bulkheads/Bulkhead Wings – Custom Preforms, 3 x E LTM 1810 (3in wide), E BXM 1208
- Deck – SK50, 2oz CSM, 2 x E LTM 1808
- Deck Framing – TR4030 (24oz 0/90), E LM 1810 uni
- Transom – SK50, 2oz CSM, 1 x E LTM 3610, Transom Preforms (24oz +/-45), bottom overlays (2 x E LM 1810), 1 x E LTM 3610

11M- Complete FEA Analysis Advanced Lamiante AL



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11M-AL- FEA Analysis: Small Area Slamming (SAS)

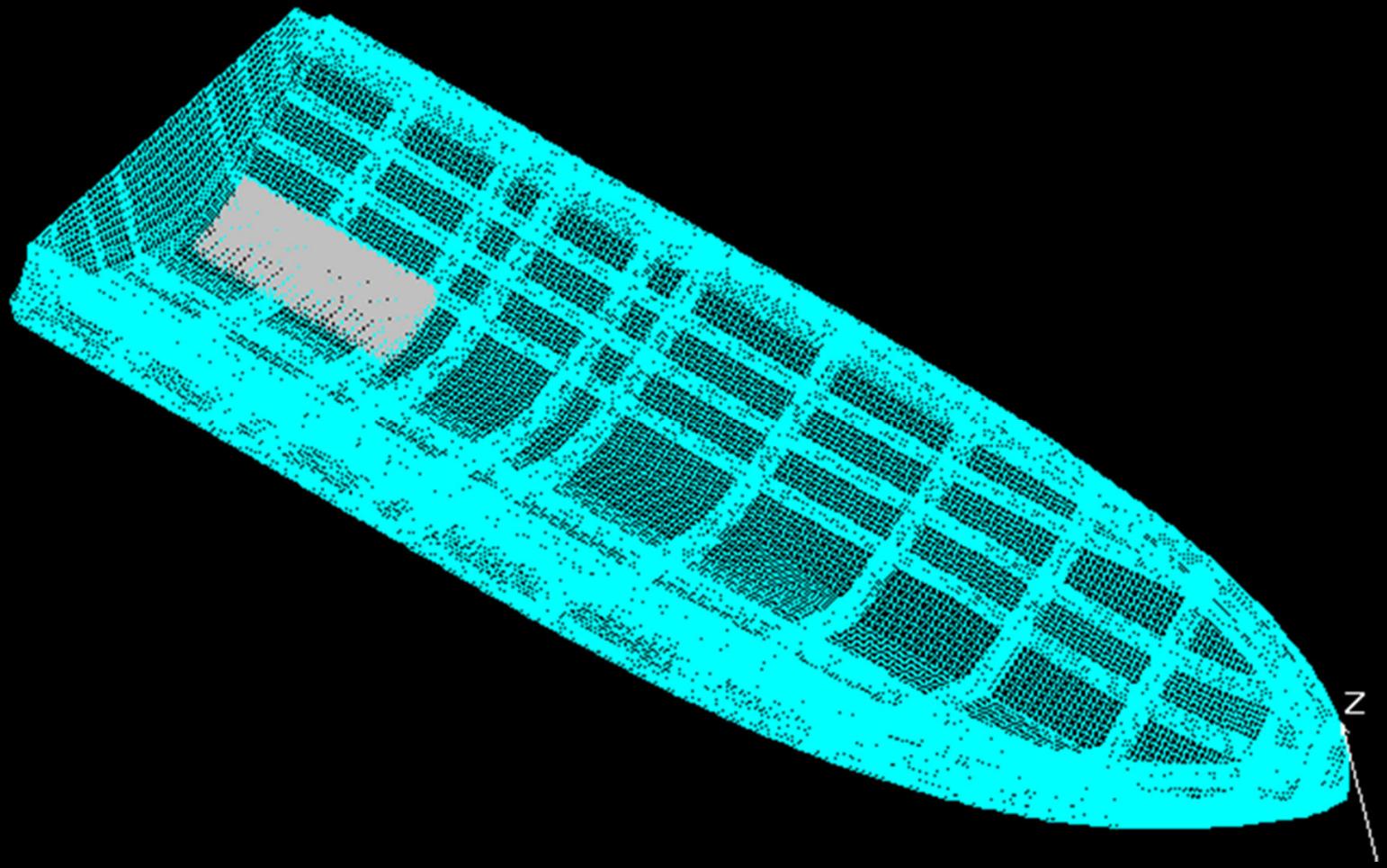


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Small Area Pressure Load

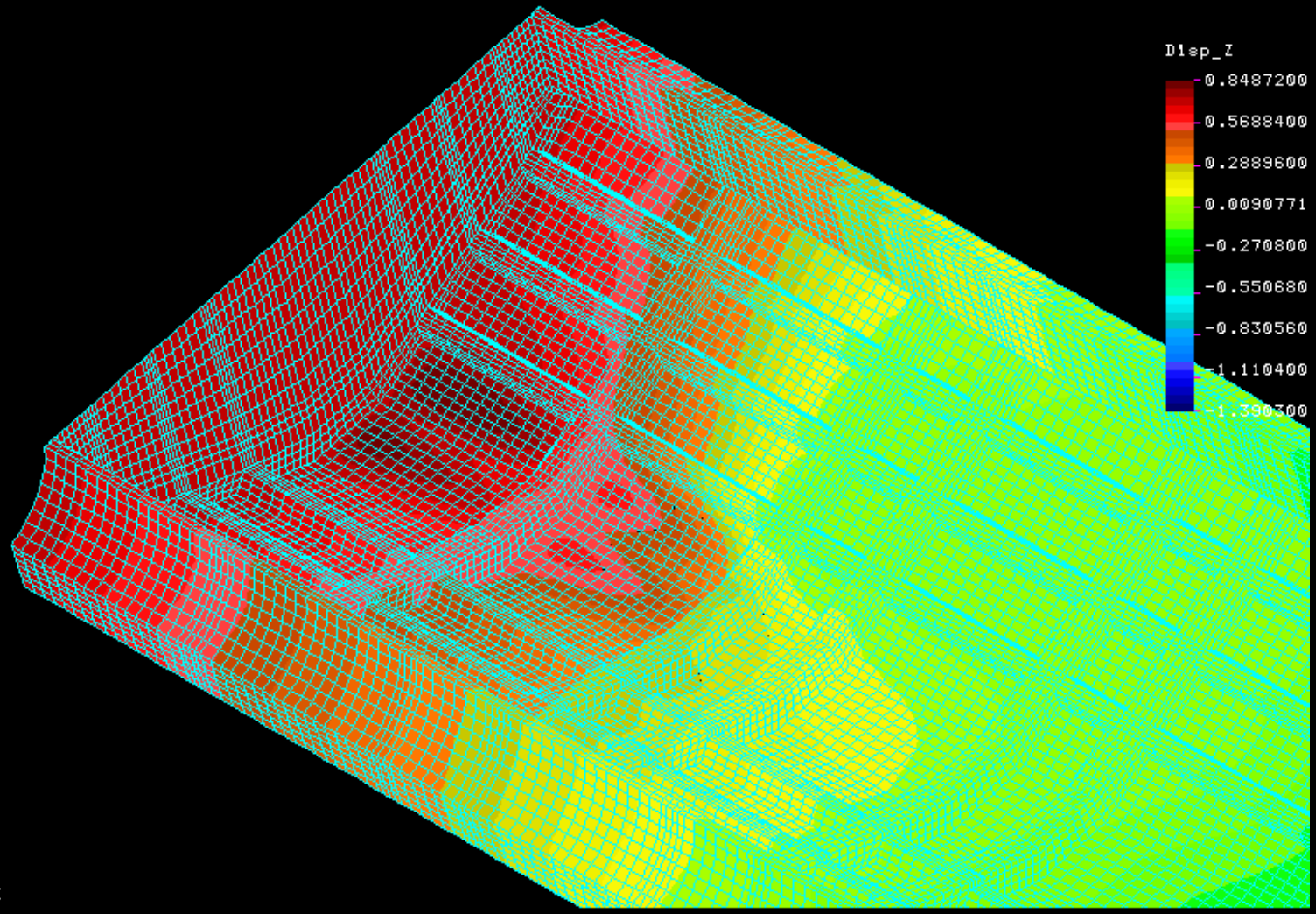
- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

LC1 - AL – AI -10 psi Pressure Load



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LC1-AL- AI- Z Hull Displacement



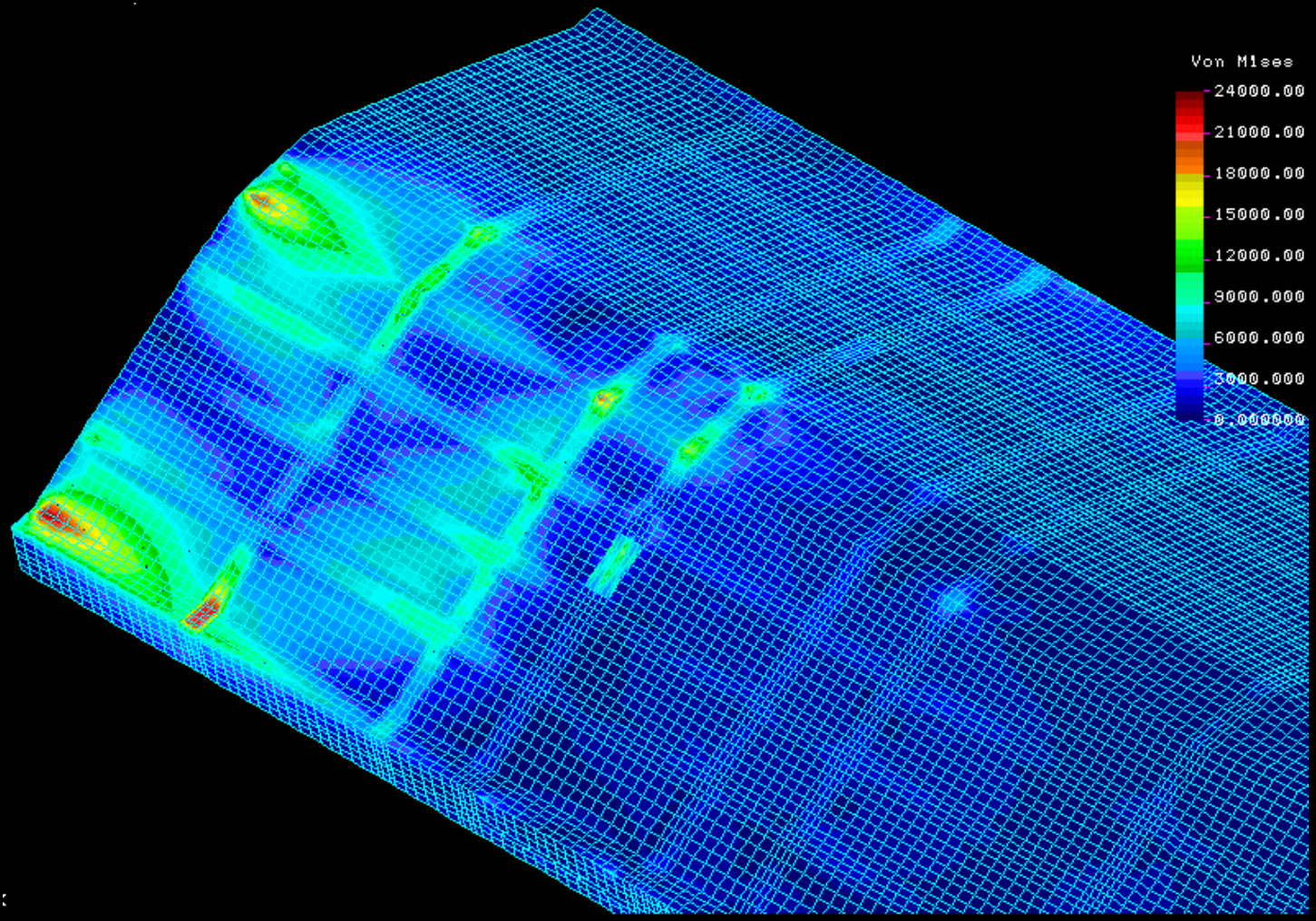
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LC1-AL - AI- Transverse Carbon Ply Stress



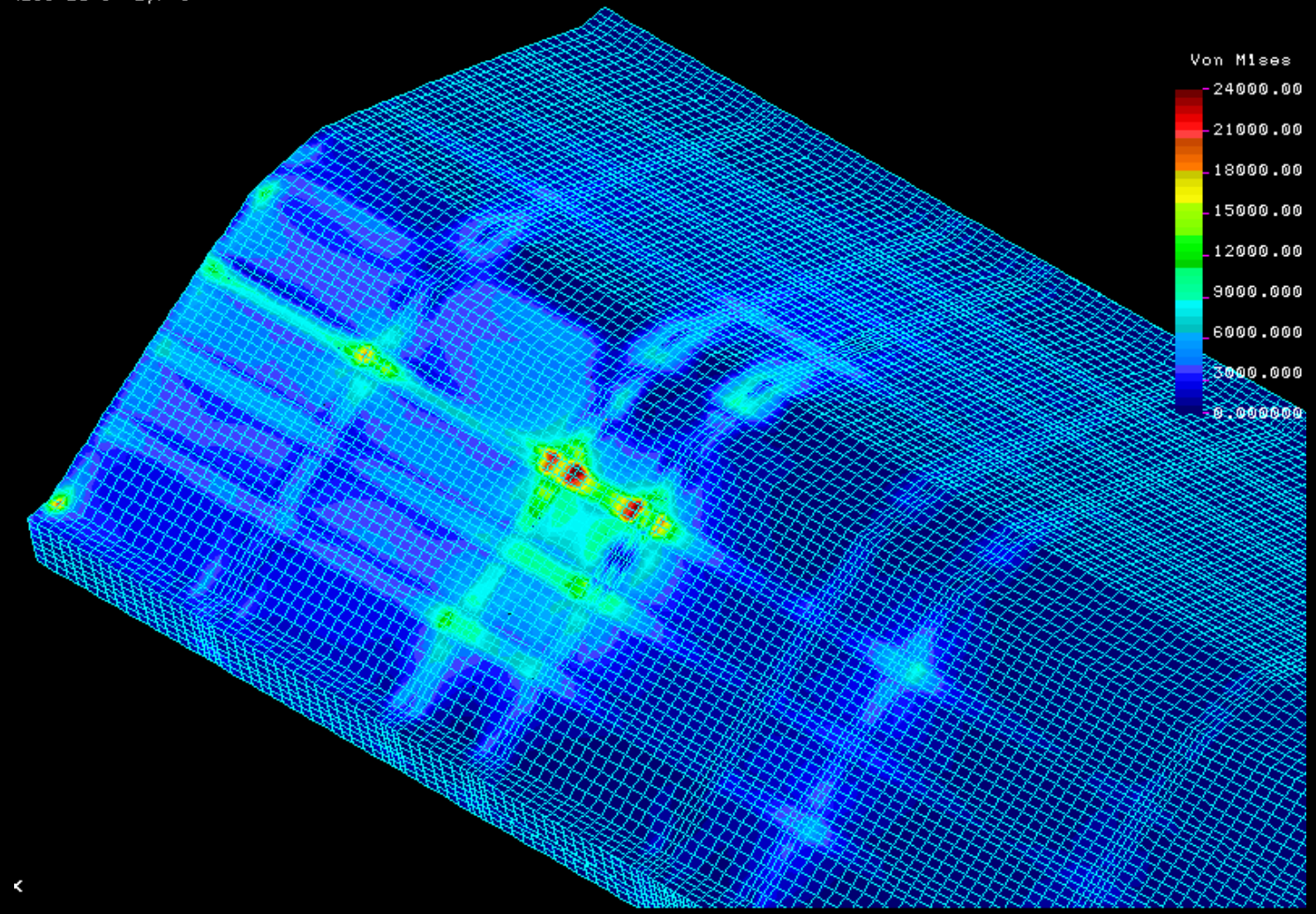
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LC1- AL - AI- Longitudinal Carbon Ply



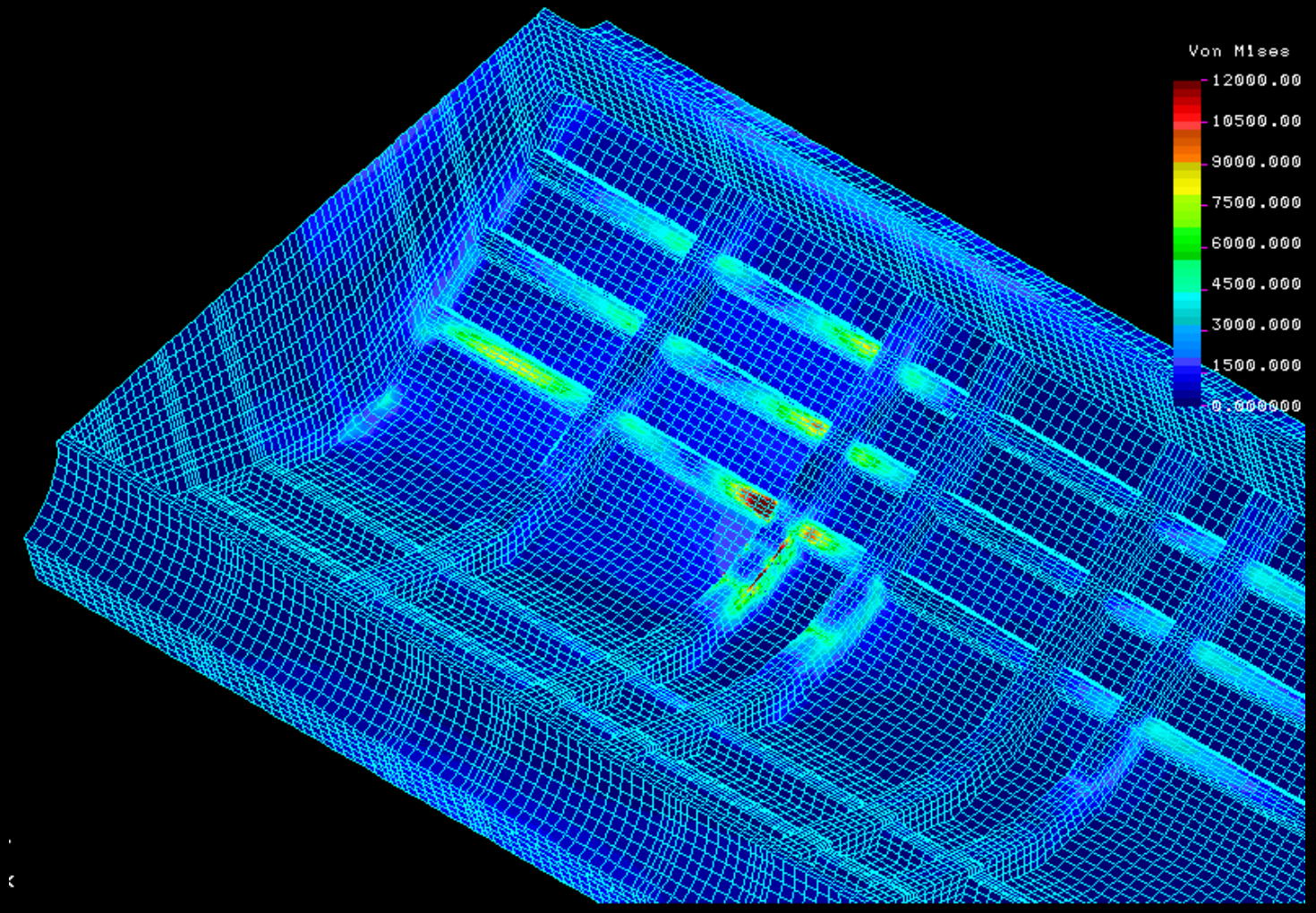
STRUCTURAL COMPOSITES ®

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LC1- AL - AI- Longitudinal Stringer Cap Stress



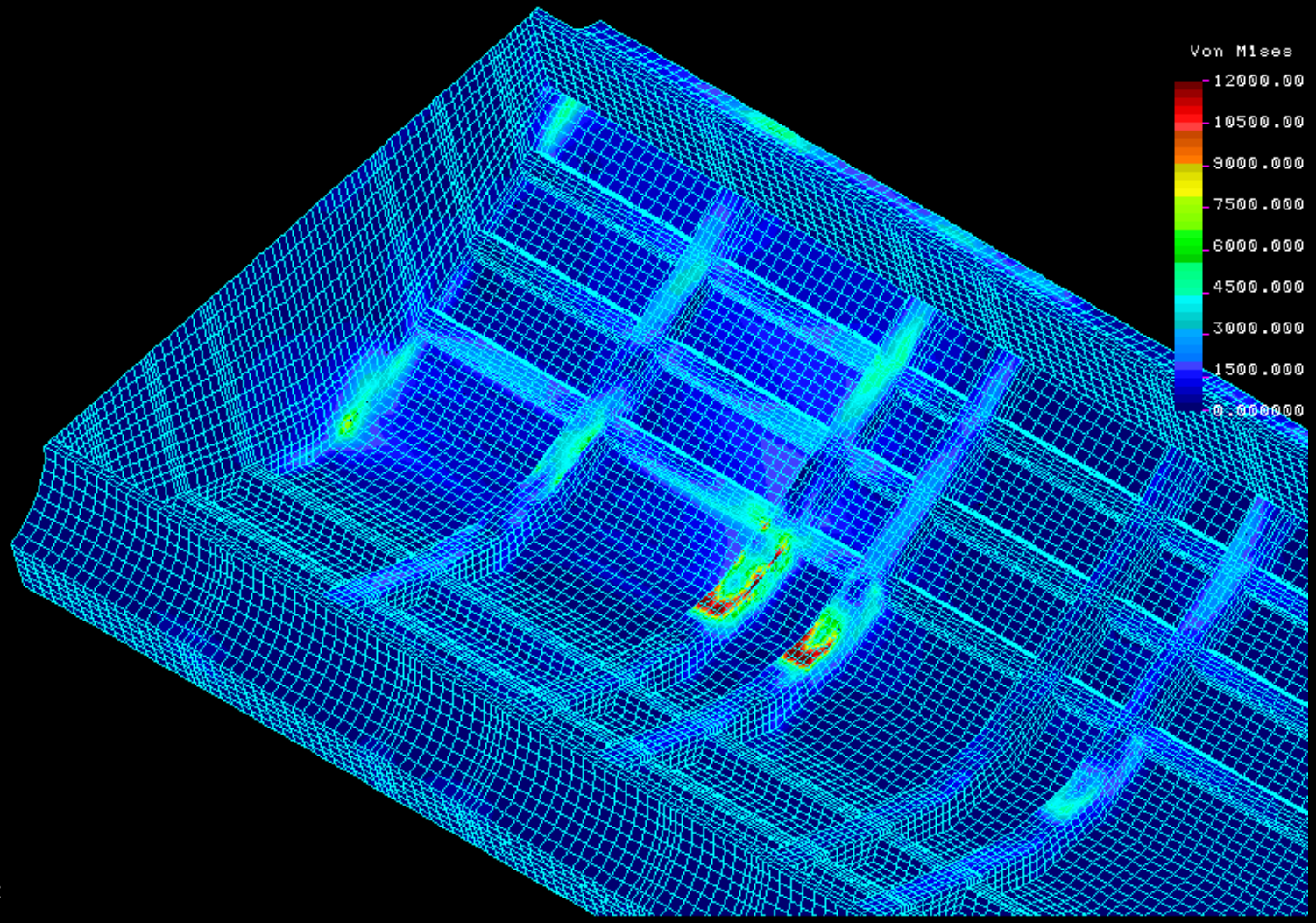
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LC1- AL - AI- Transverse Frame Cap Stress



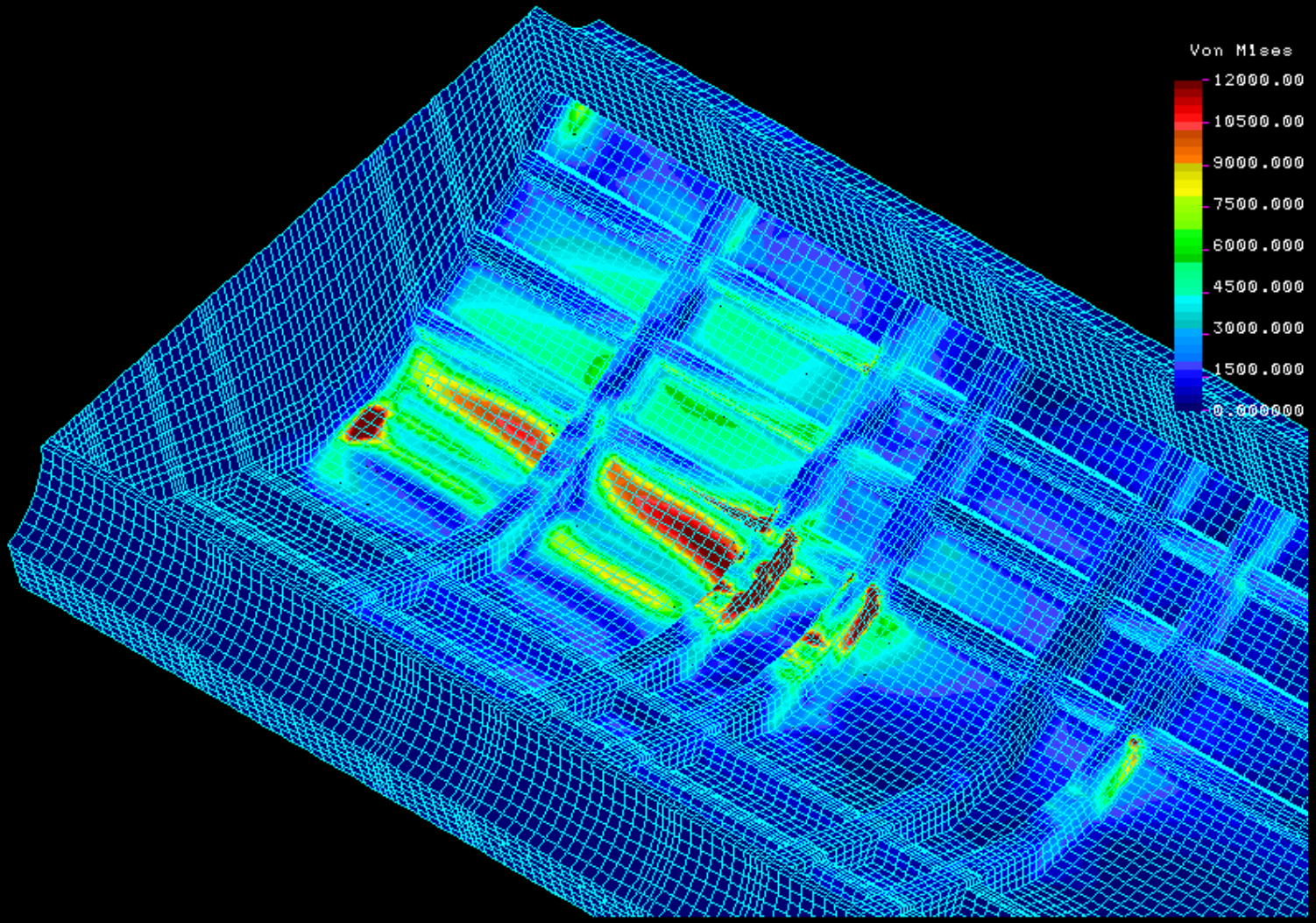
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LC1- AL - AI- 45 Ply Tab and Sidewall Stress



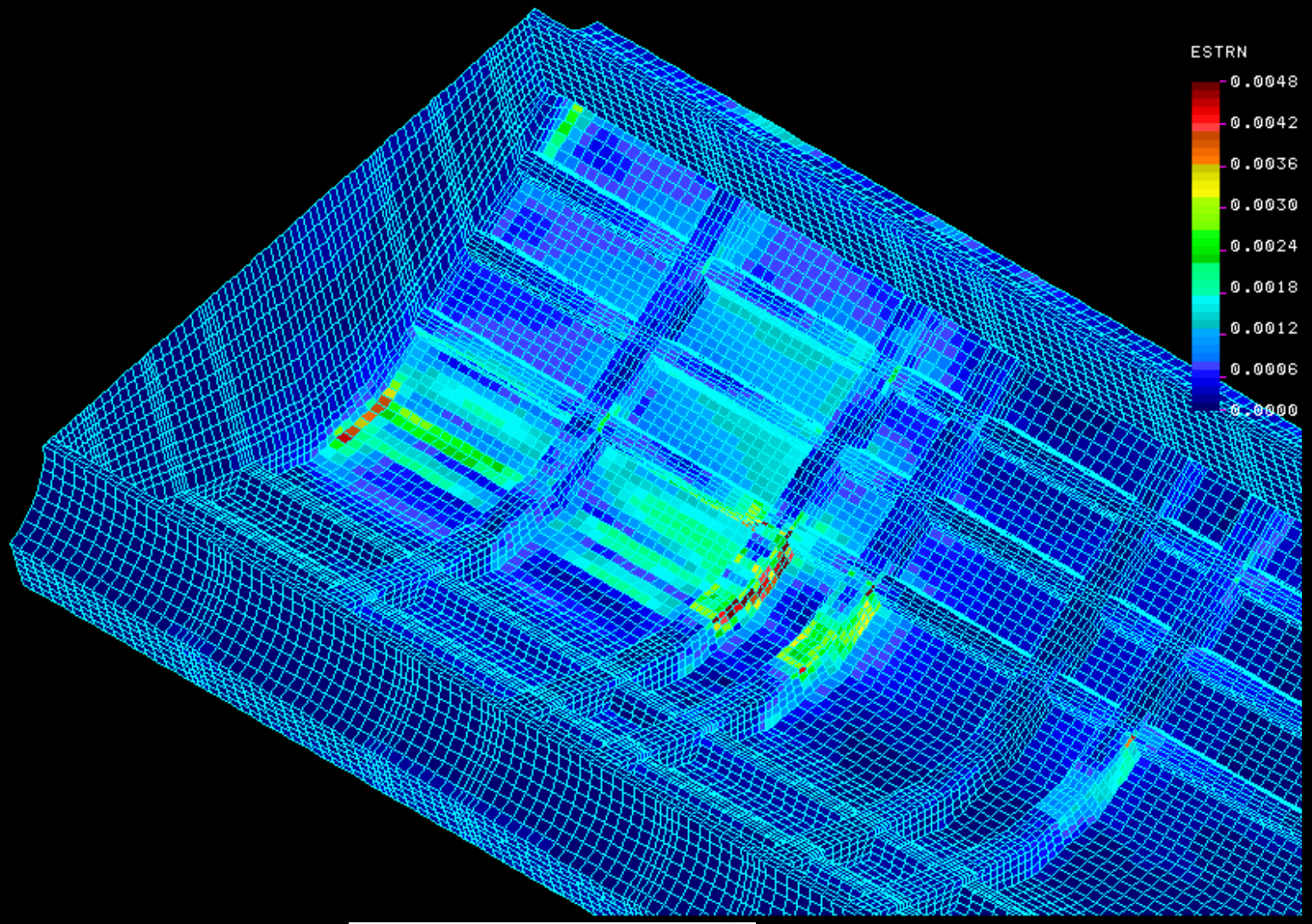
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LC1-AL - Al- Inside Surface Strain



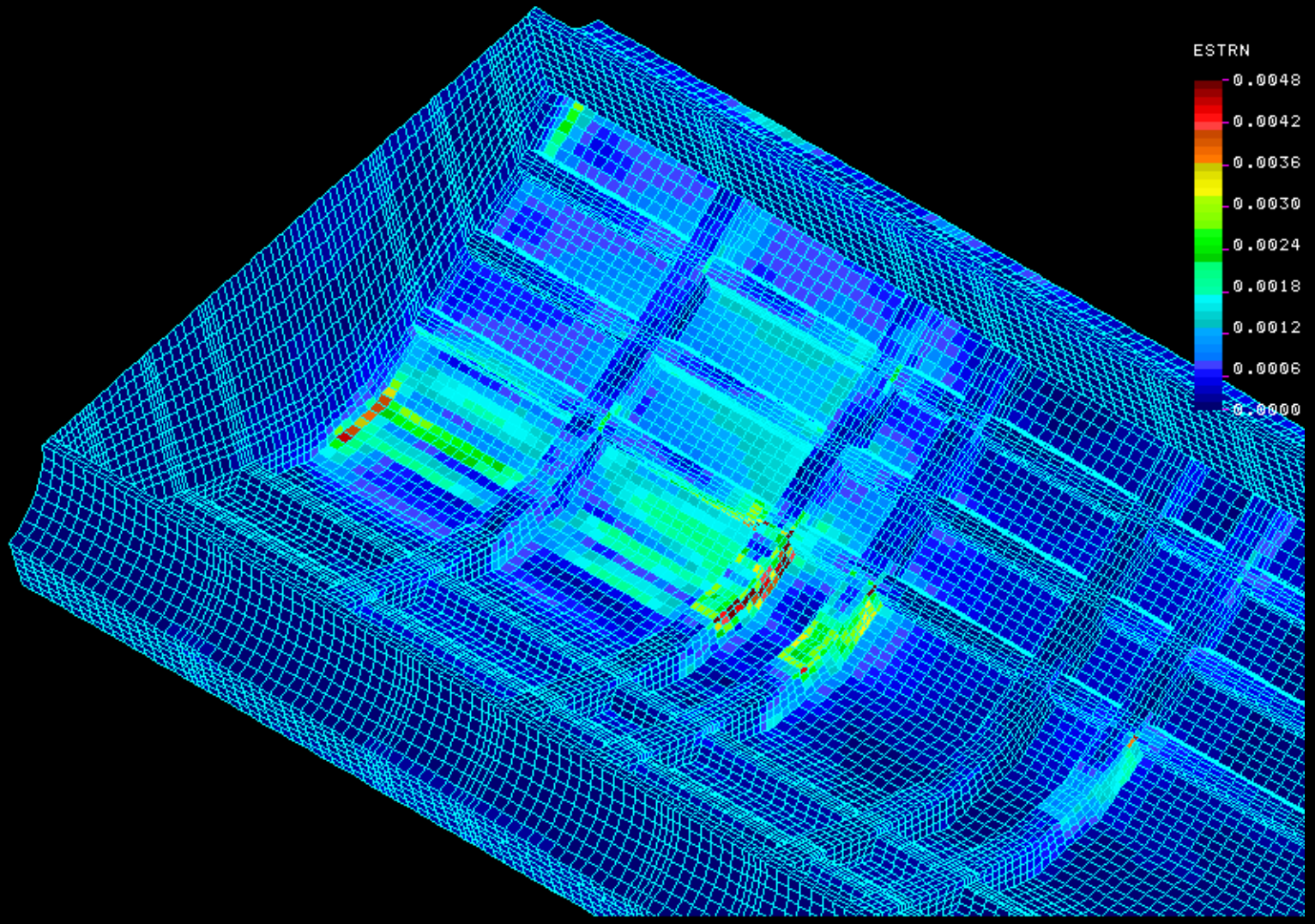
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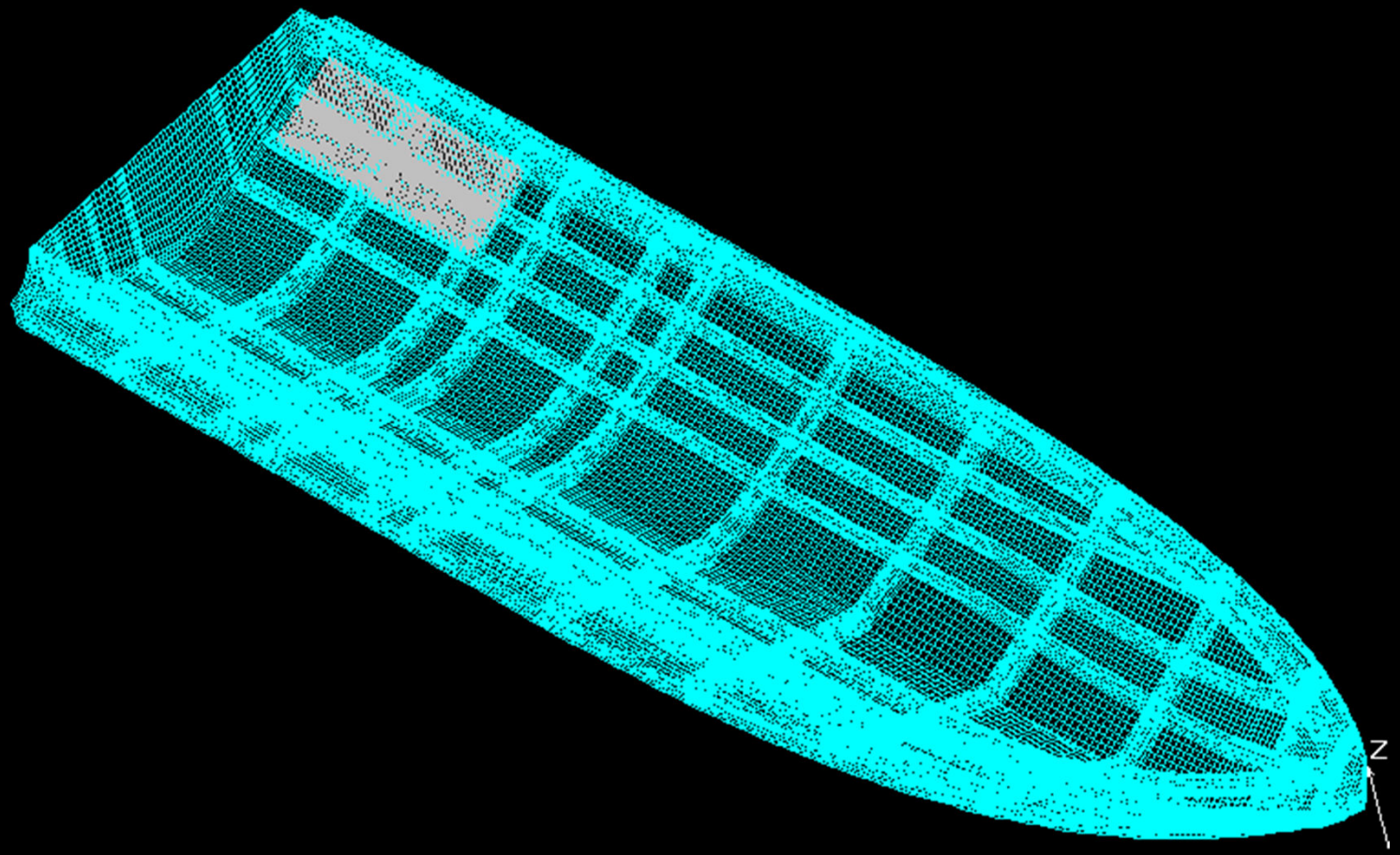
LC1-AL – AI - Outside Surface Strain



LC1- AL - AI- Summary

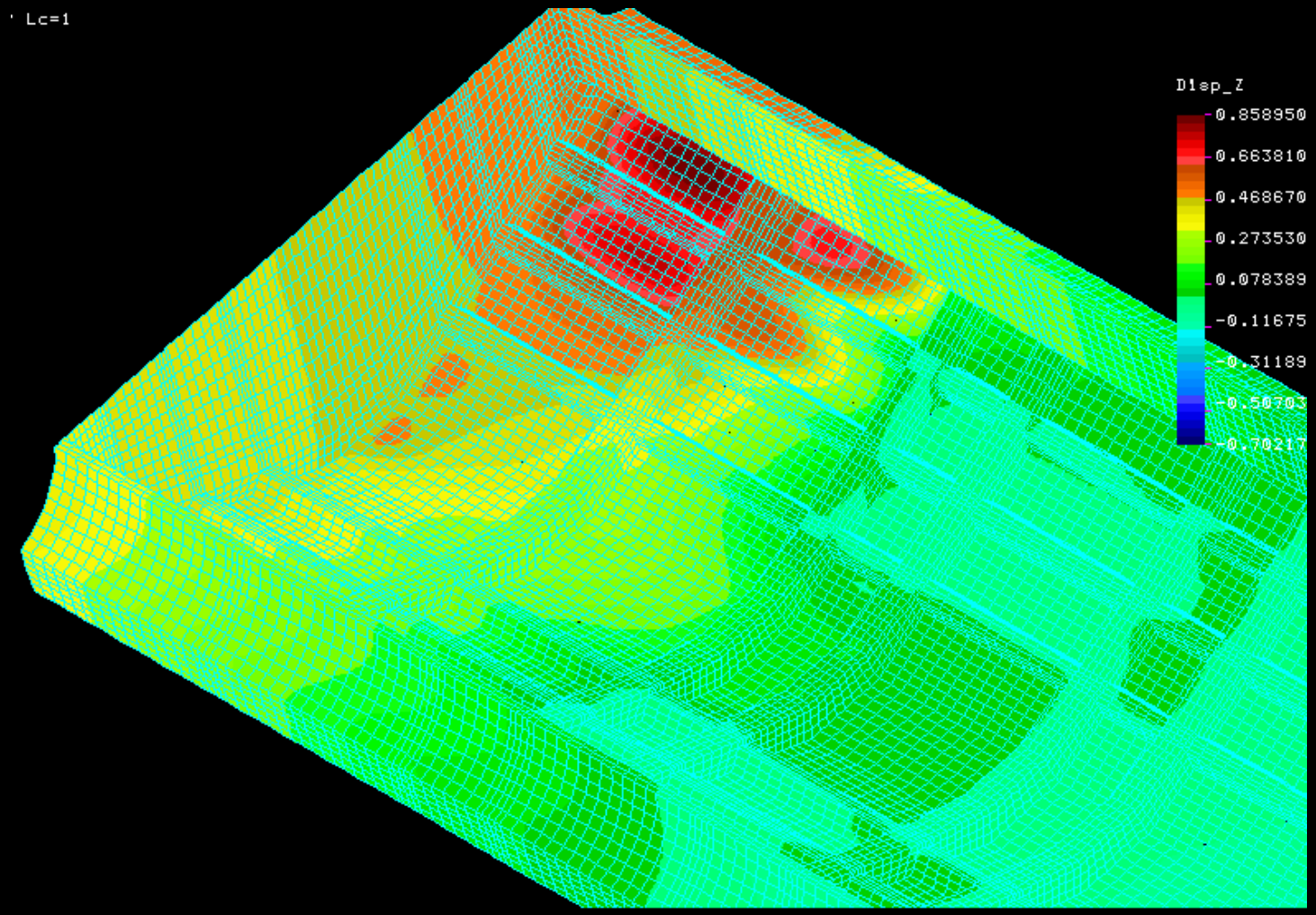
- Hull range of deflection to 2.24 in.
- Maximum Hull strain 0.0033 in/in
- Maximum Hull stress 24,000
- Maximum framing strain 0.0048
- Maximum framing stress 12,000 psi

LC2 – AL – AO -10 psi Pressure Load



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LC2 - AL- AO- Z Hull Displacement



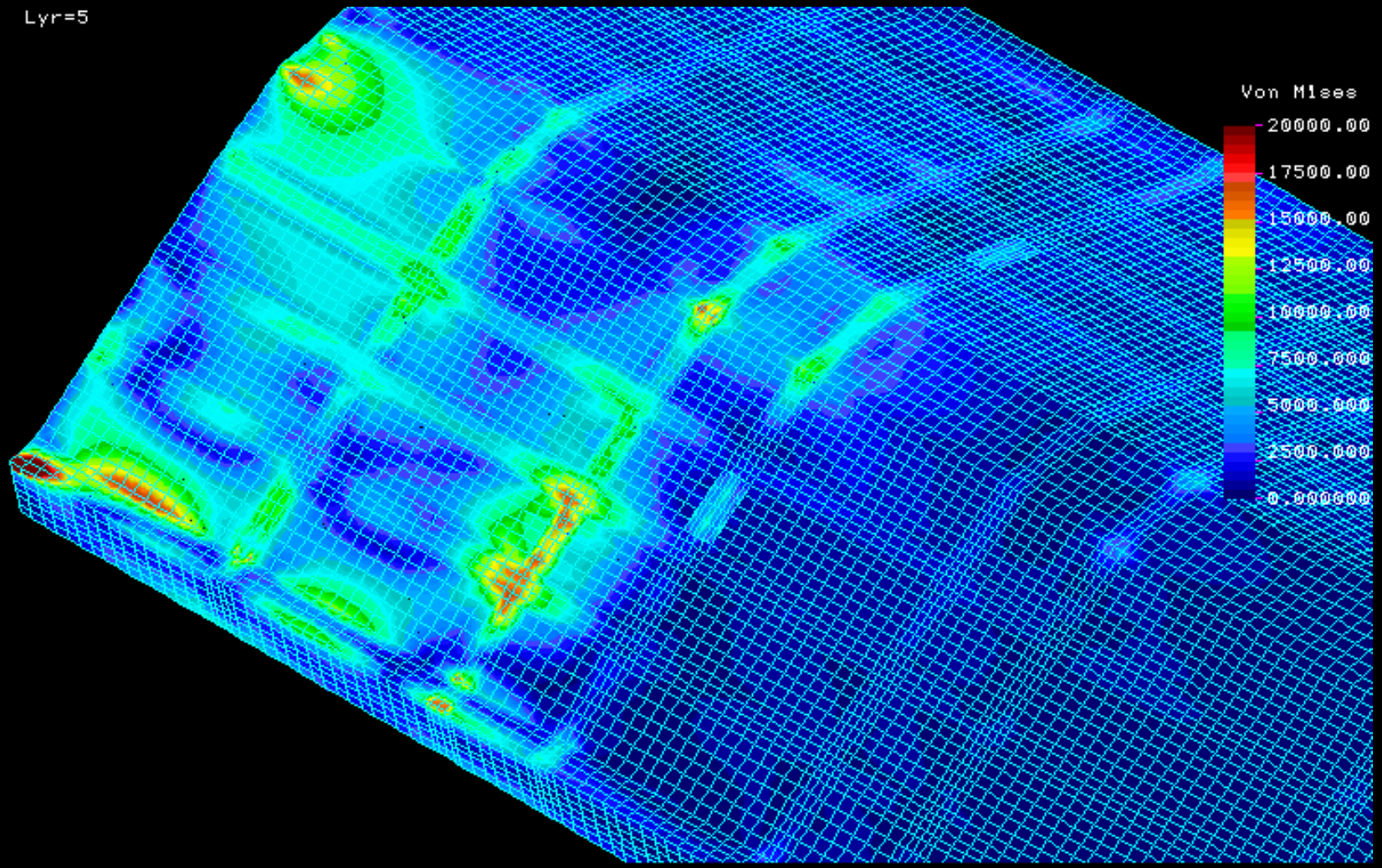
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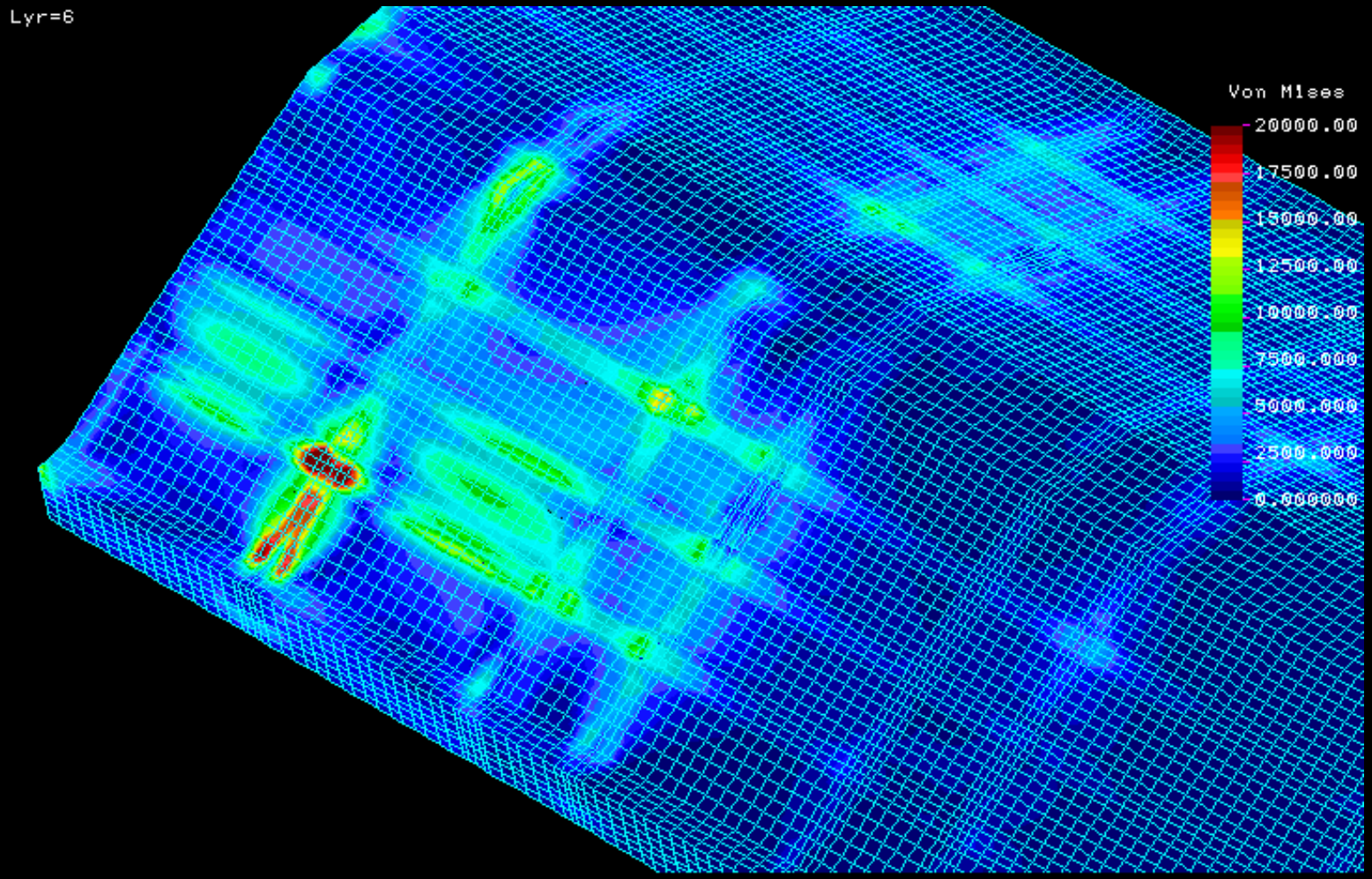
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LC2 – AL –AO- Transverse Carbon Ply Stress



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LC2- AL- AO- Longitudinal Carbon Ply Stress



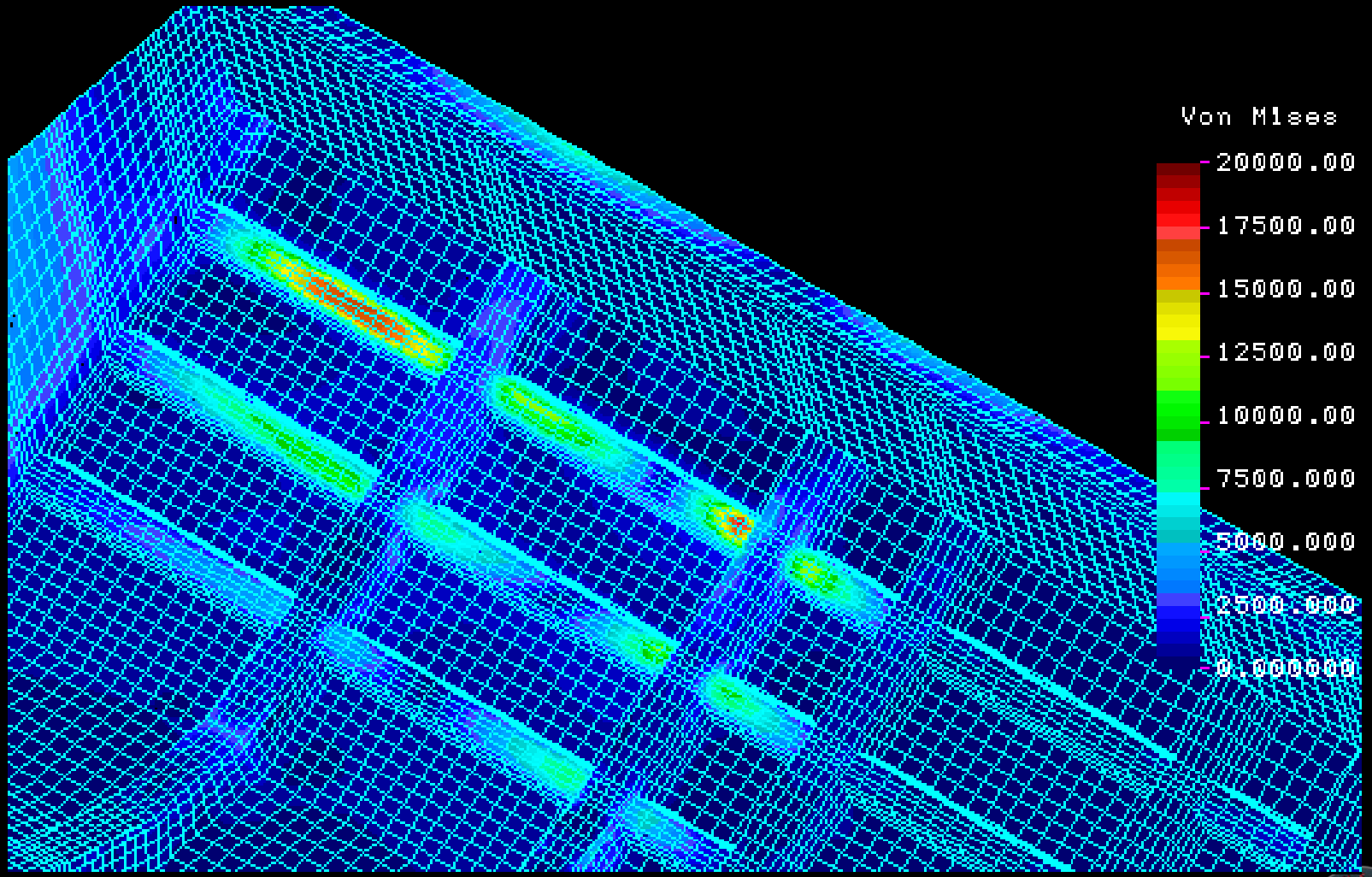
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LC2-AL- AO- Longitudinal Stringer Cap Stress



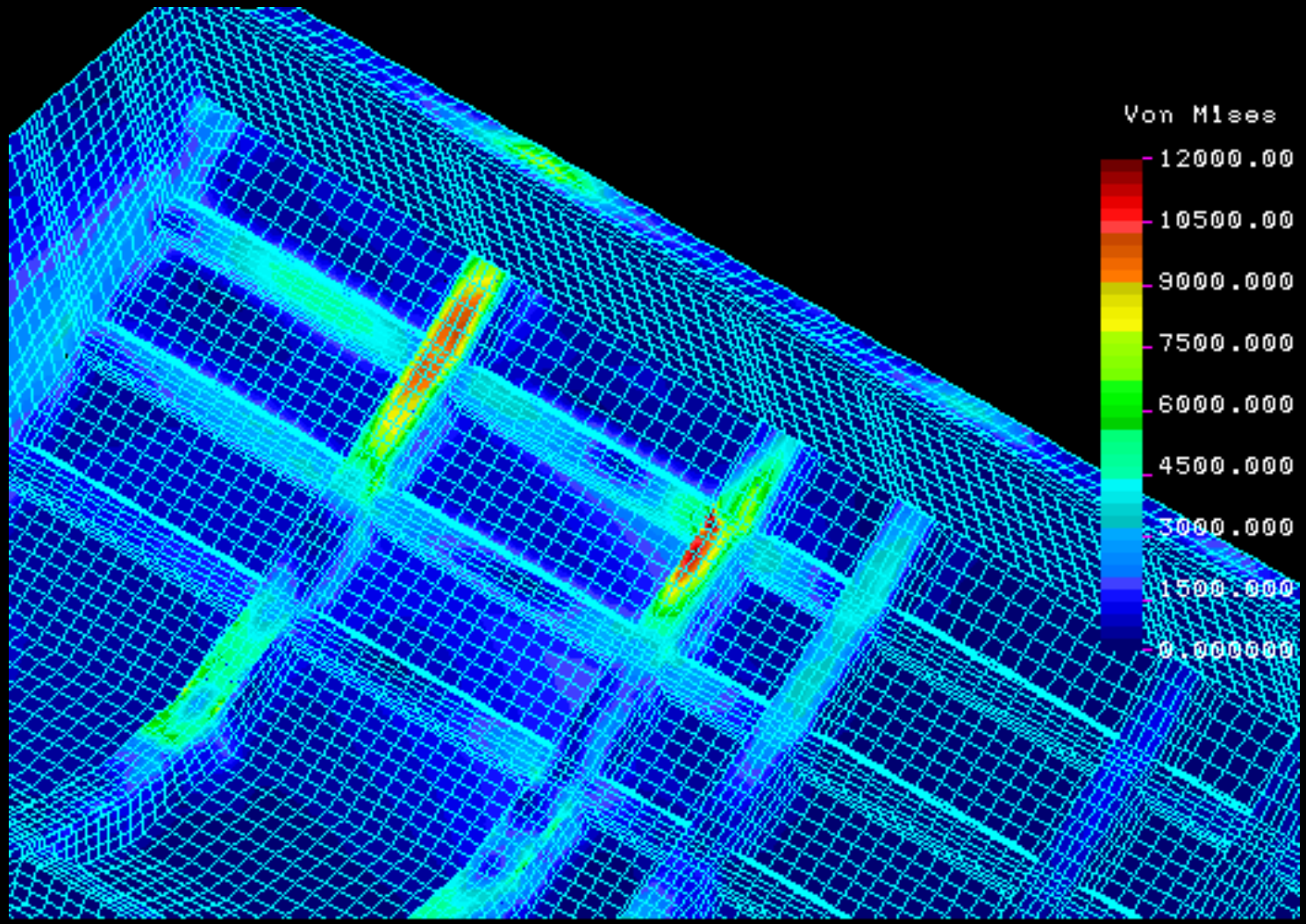
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LC2-AL- AO- Transverse Frame Cap Stress



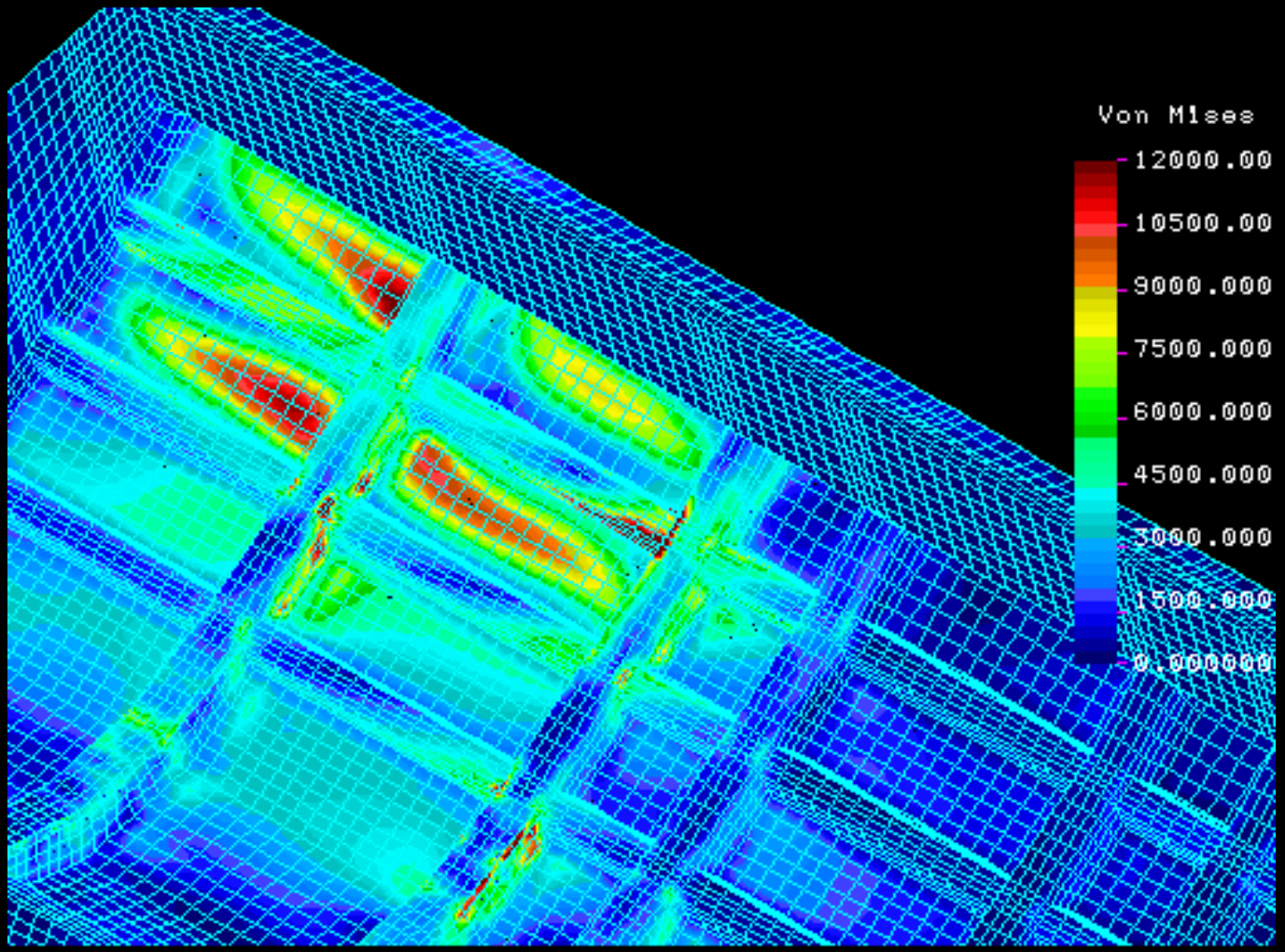
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LC2-AL - AO- 45 Ply Tab and Sidewall Stress



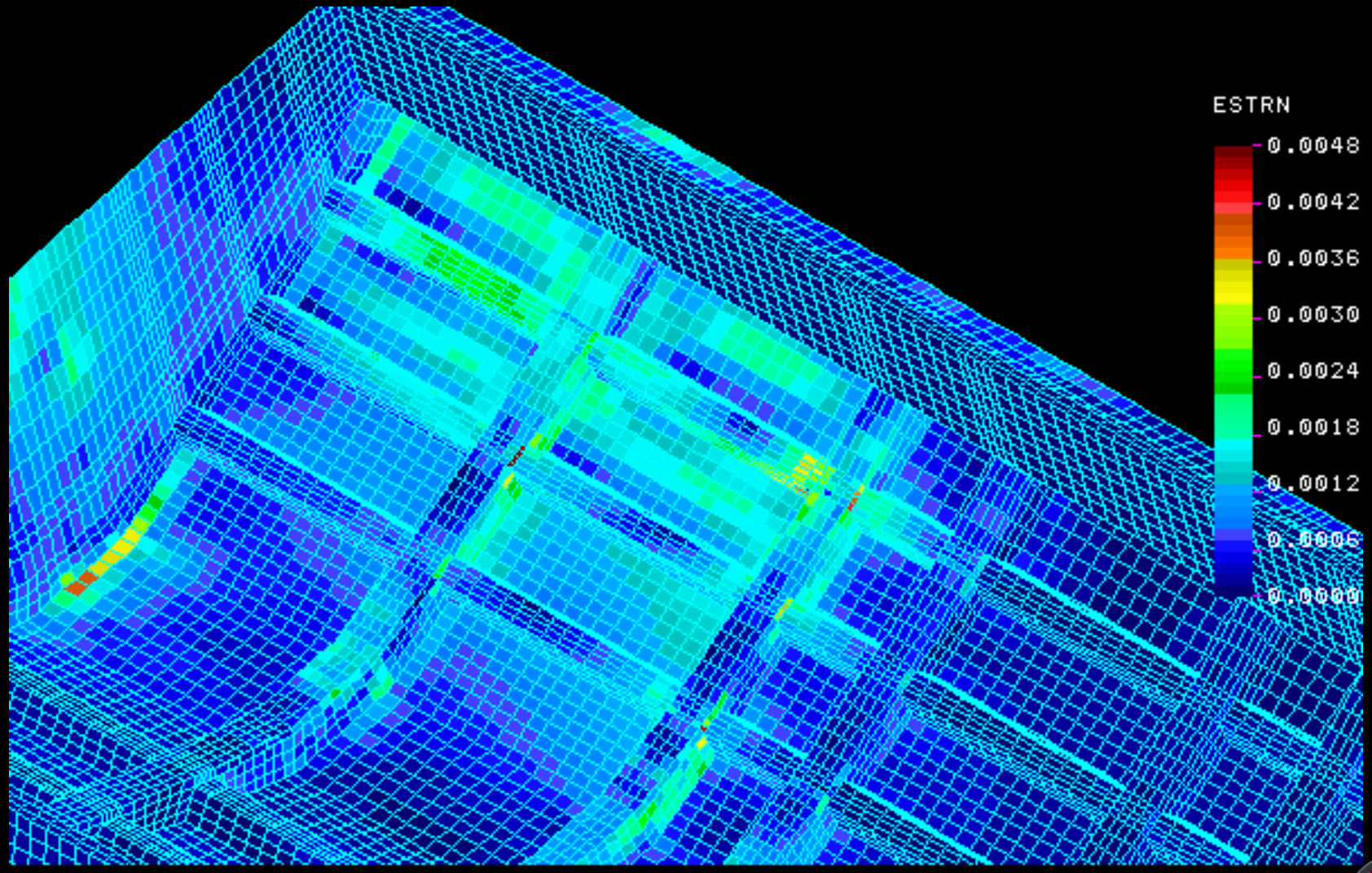
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LC2 - AL - AO- Inside Surface Strain



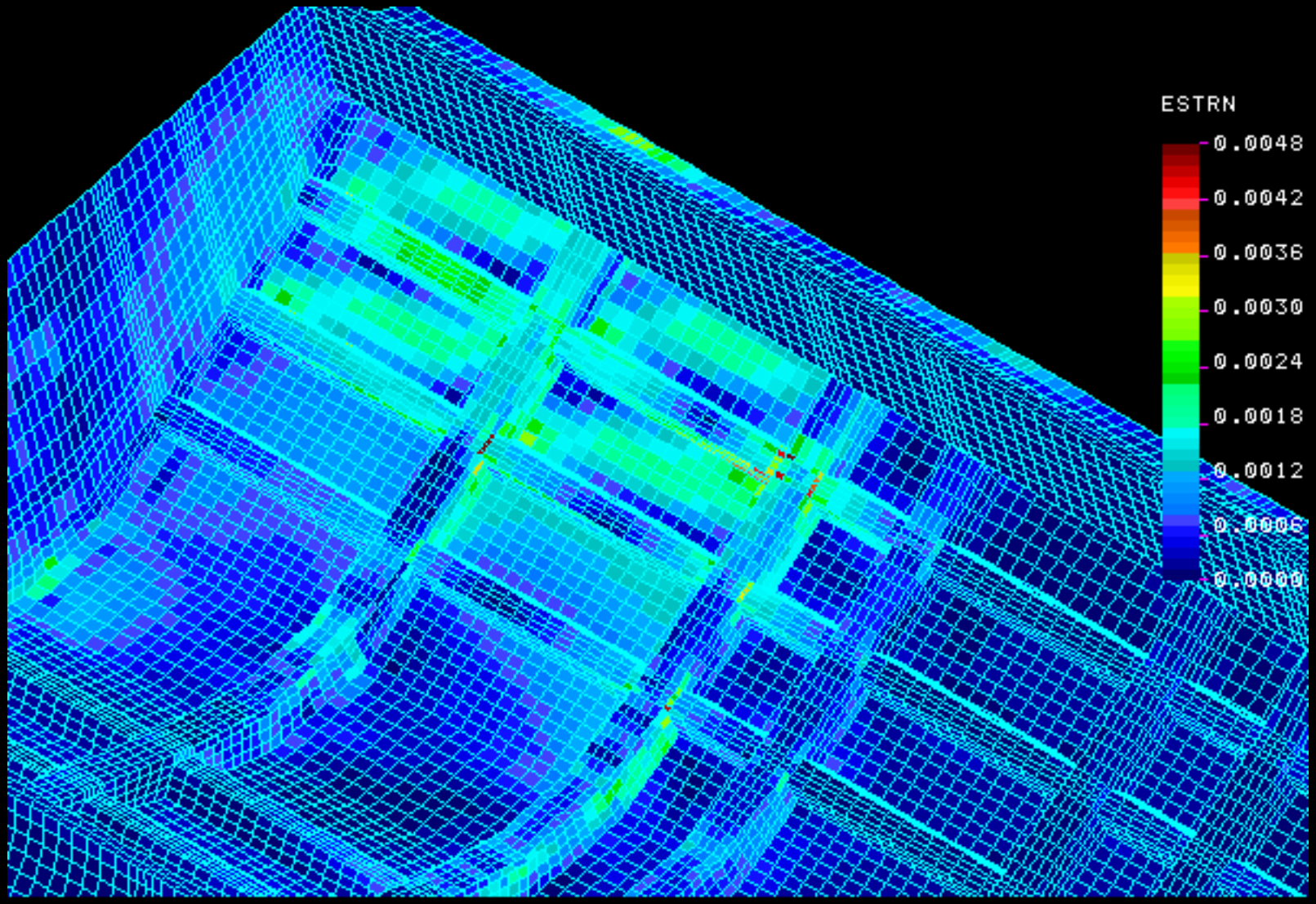
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LC2 – AL – AO - Outside Surface Strain

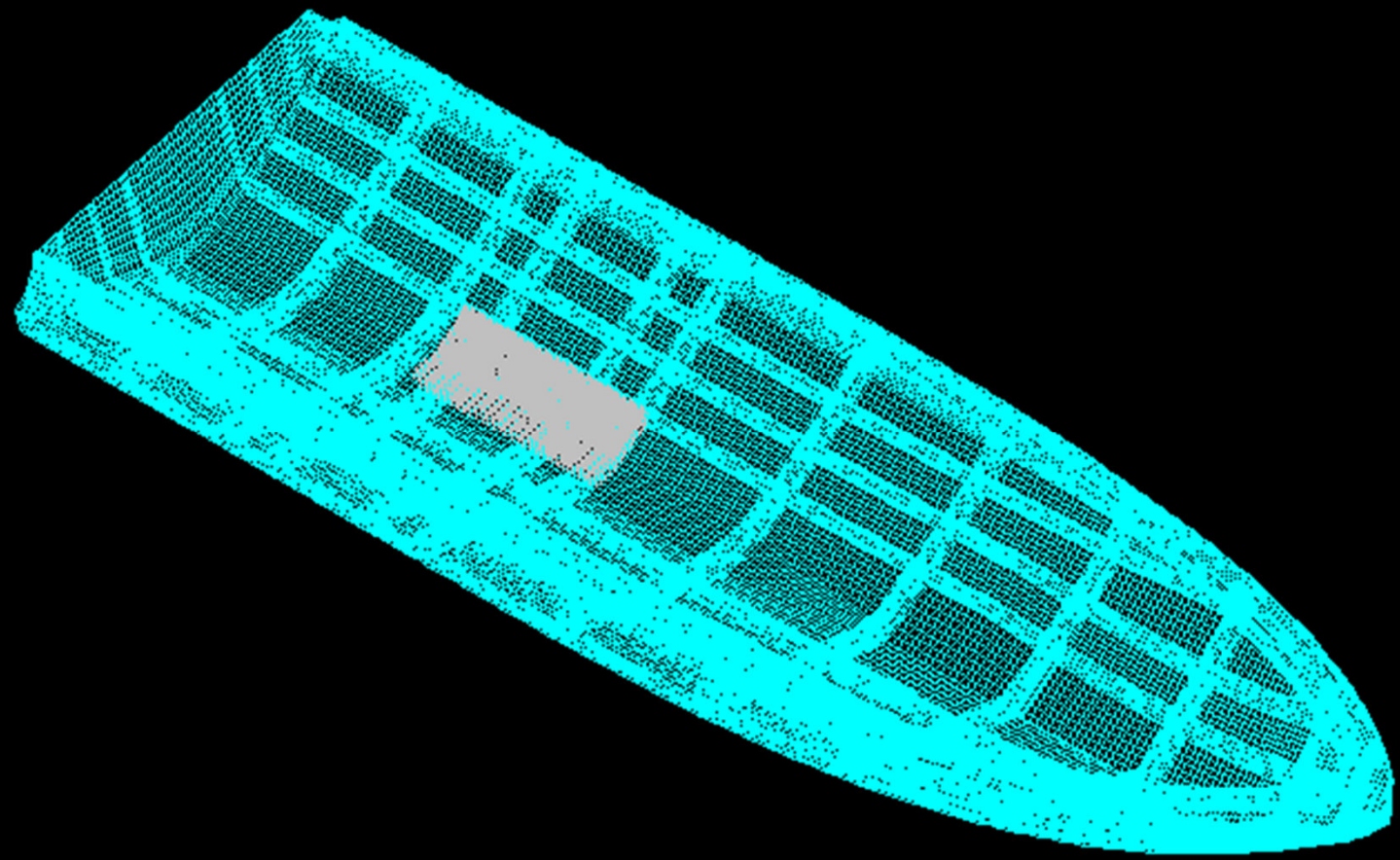


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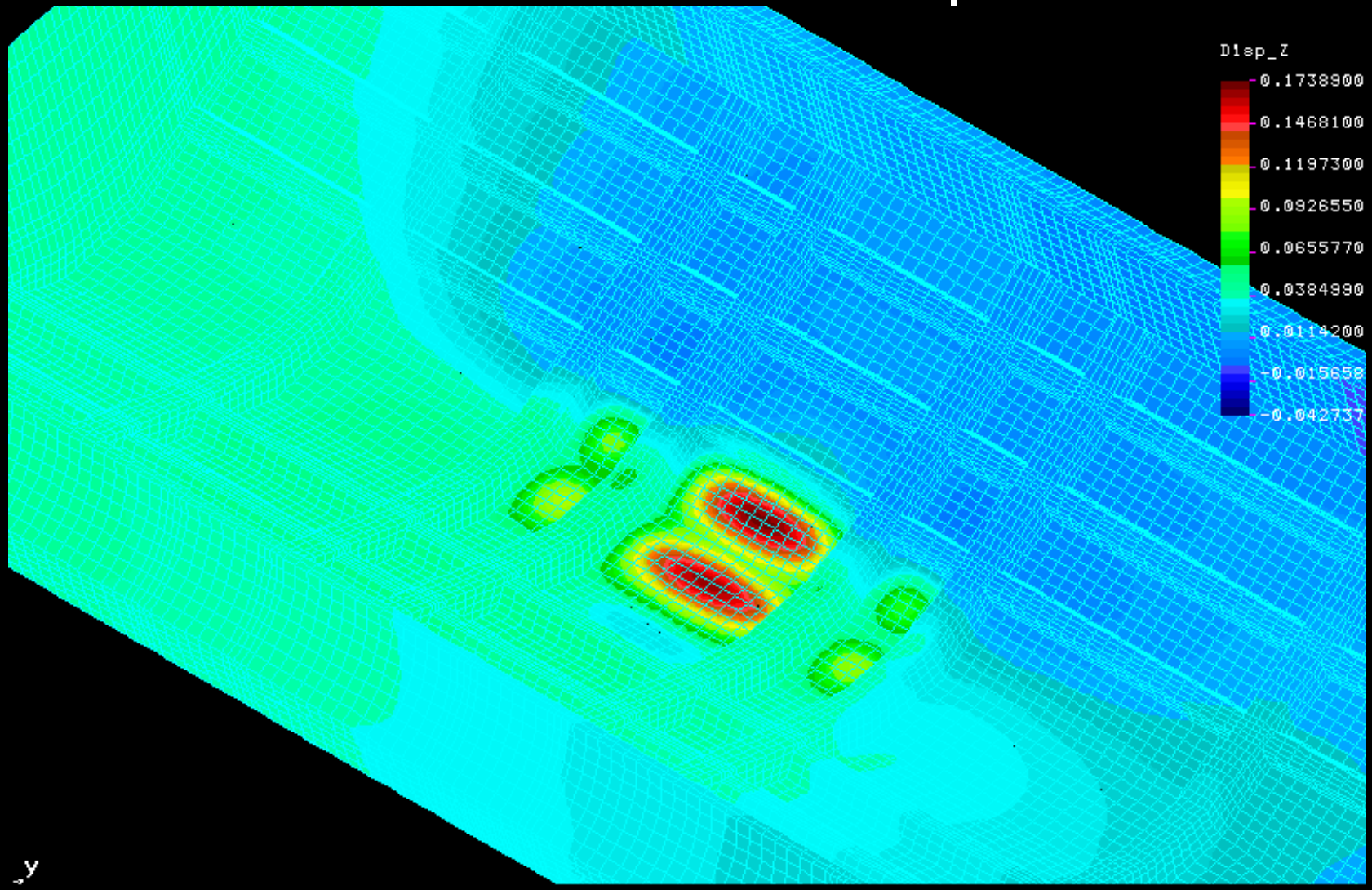
LC2 – AL – AO - Summary

- Hull range of deflection to 1.56 in
- Maximum Hull strain 0.0027 in/in
- Maximum Hull stress 20,000
- Maximum framing strain 0.0036
- Maximum framing stress 16,000 psi

LC3 - AL- AMI-10 psi Pressure Load



LC3 – AL – AMI - Z Hull Displacement



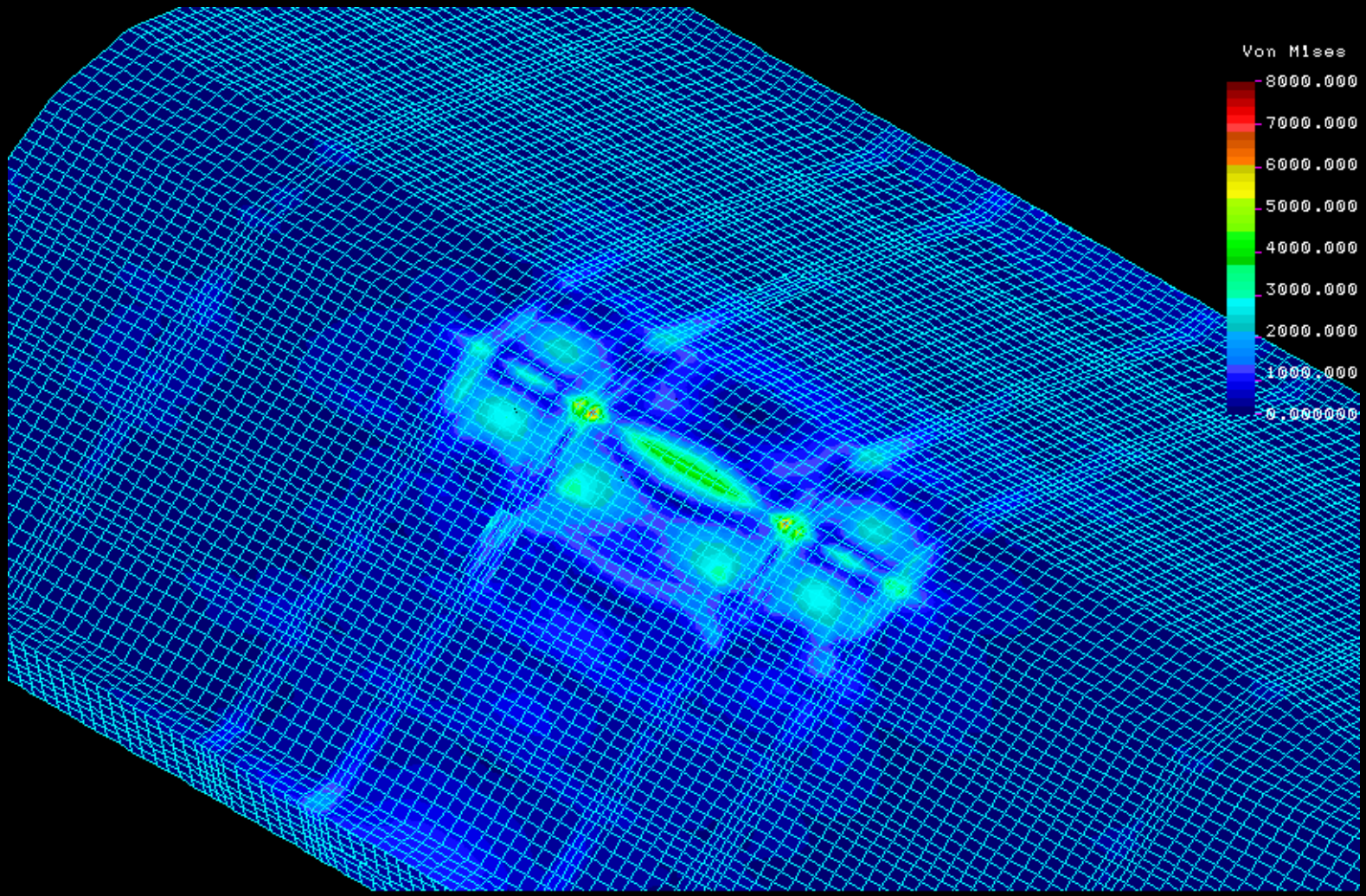
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LC3 - AL- AMI- Transverse Carbon Ply Stress



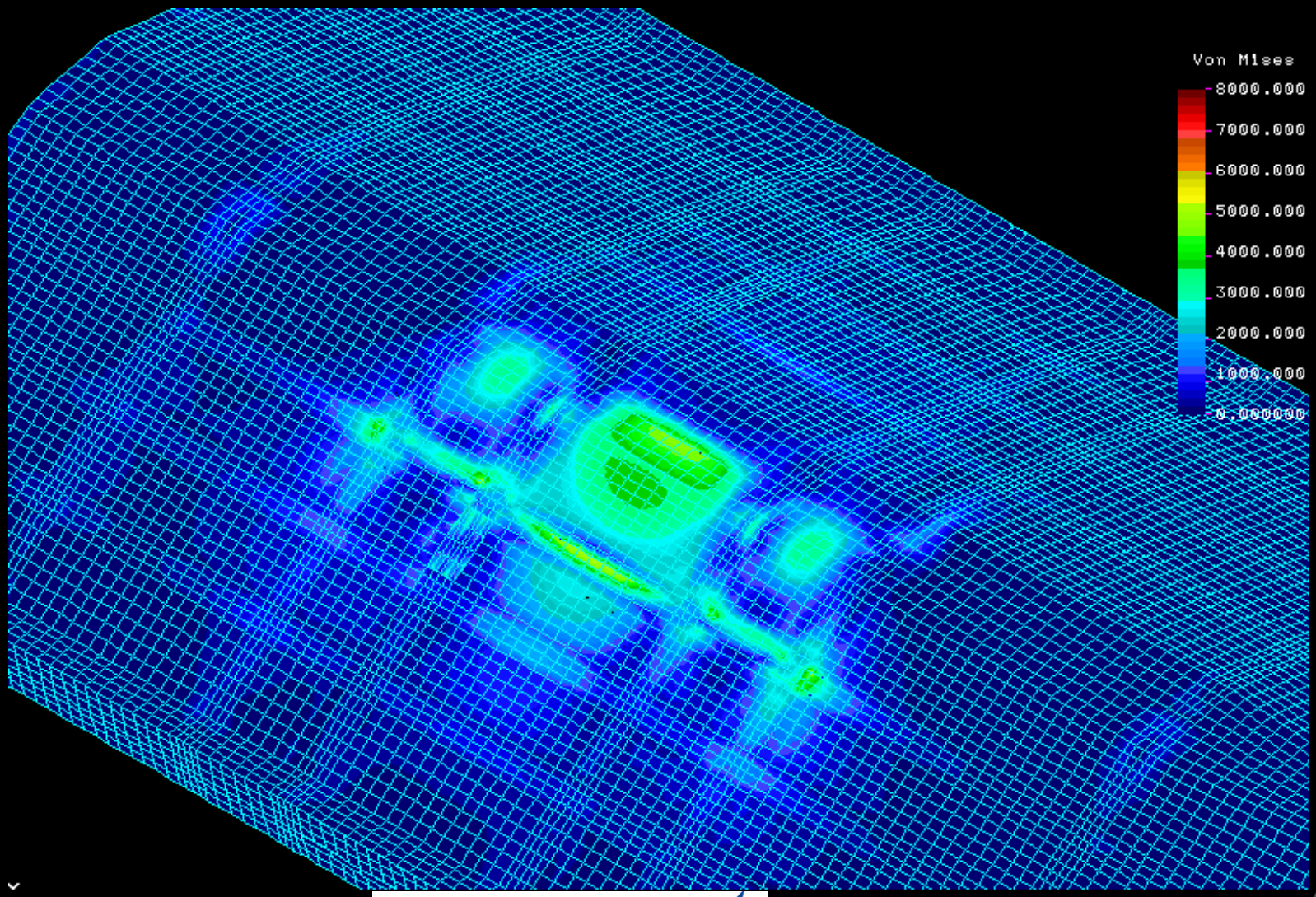
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LC3-AL-AMI- Longitudinal Carbon Ply Stress



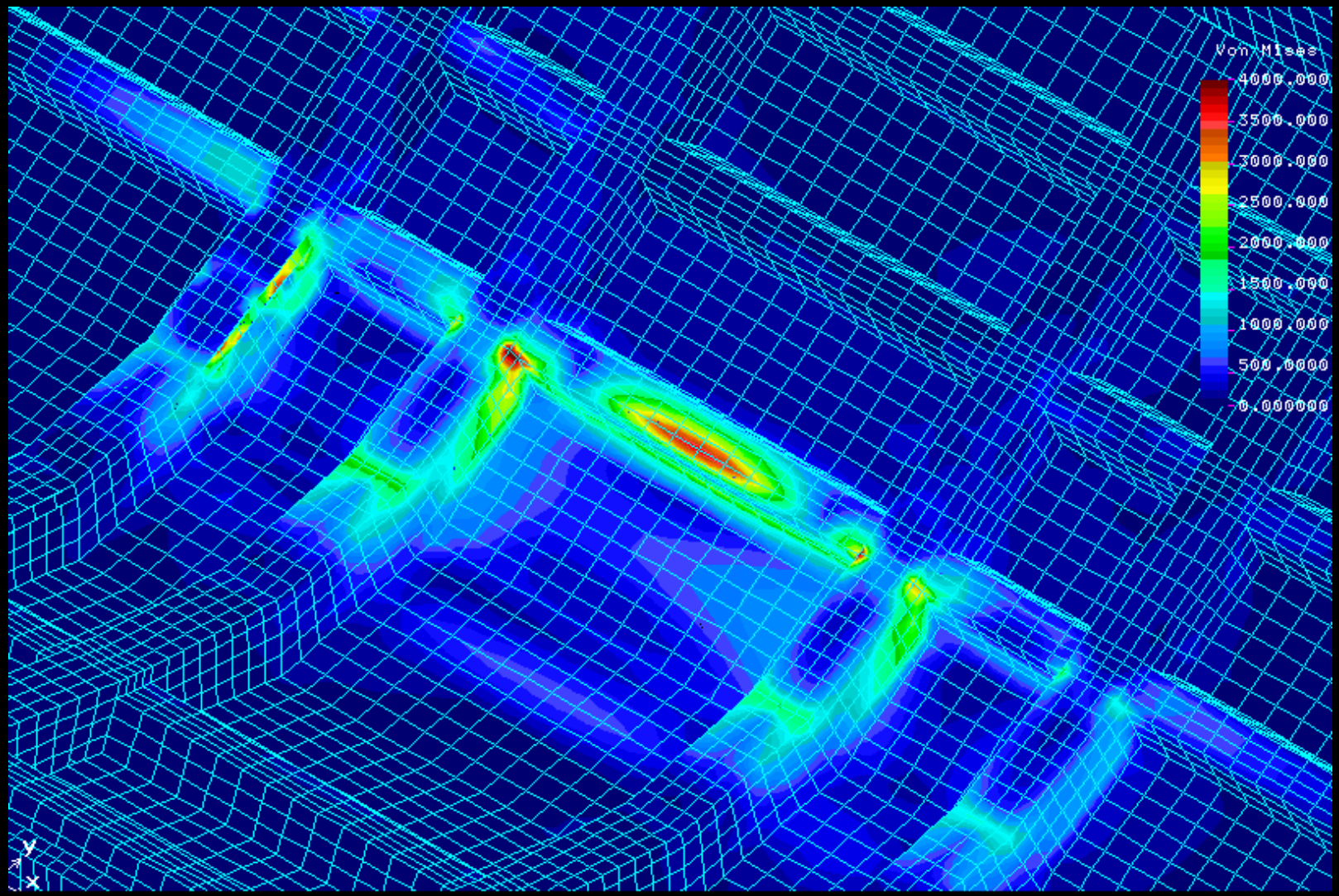
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LC3-AL- AMI- Longitudinal Stringer Cap Stress



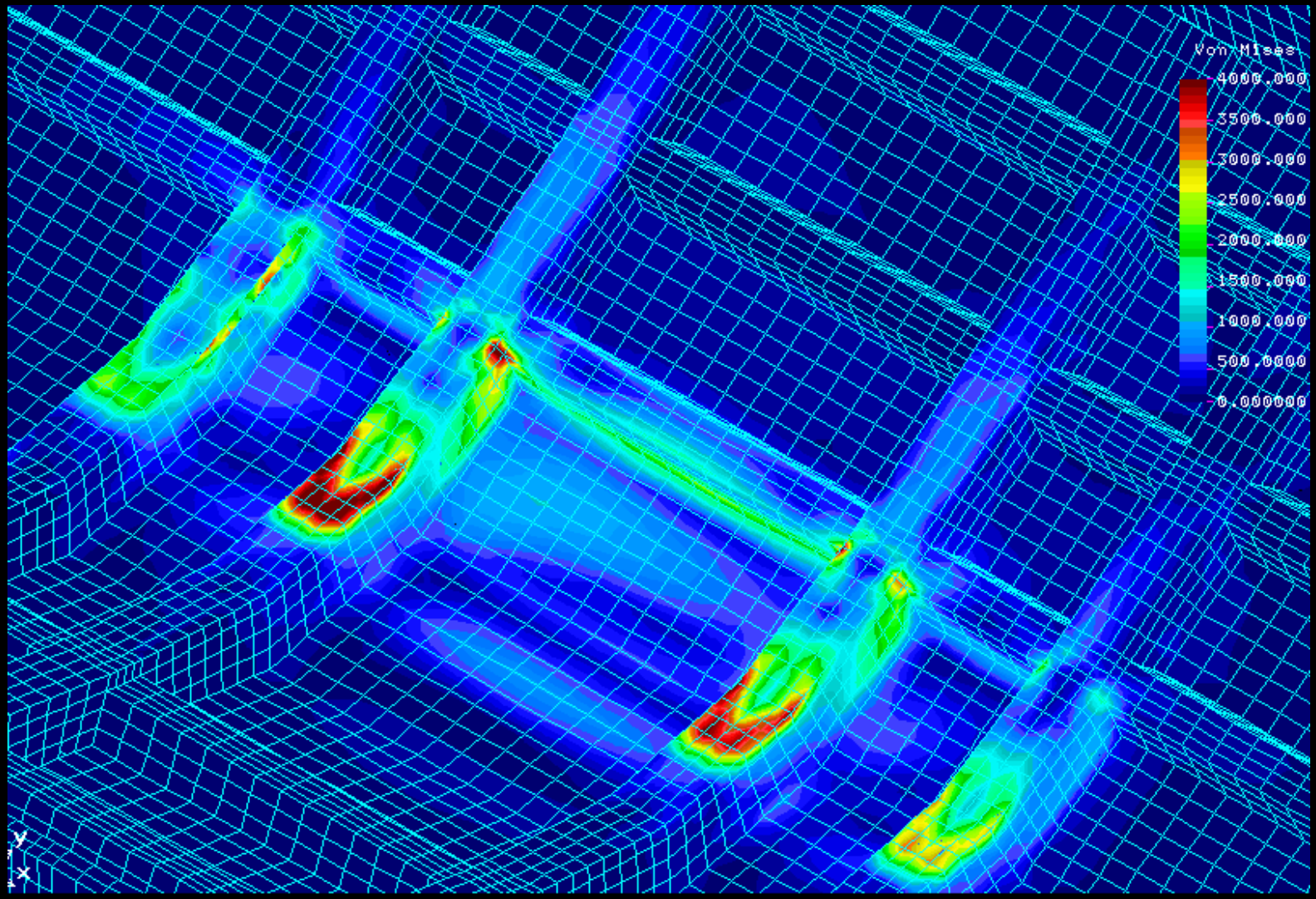
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LC3-AL- AMI- Transverse Frame Cap Stress



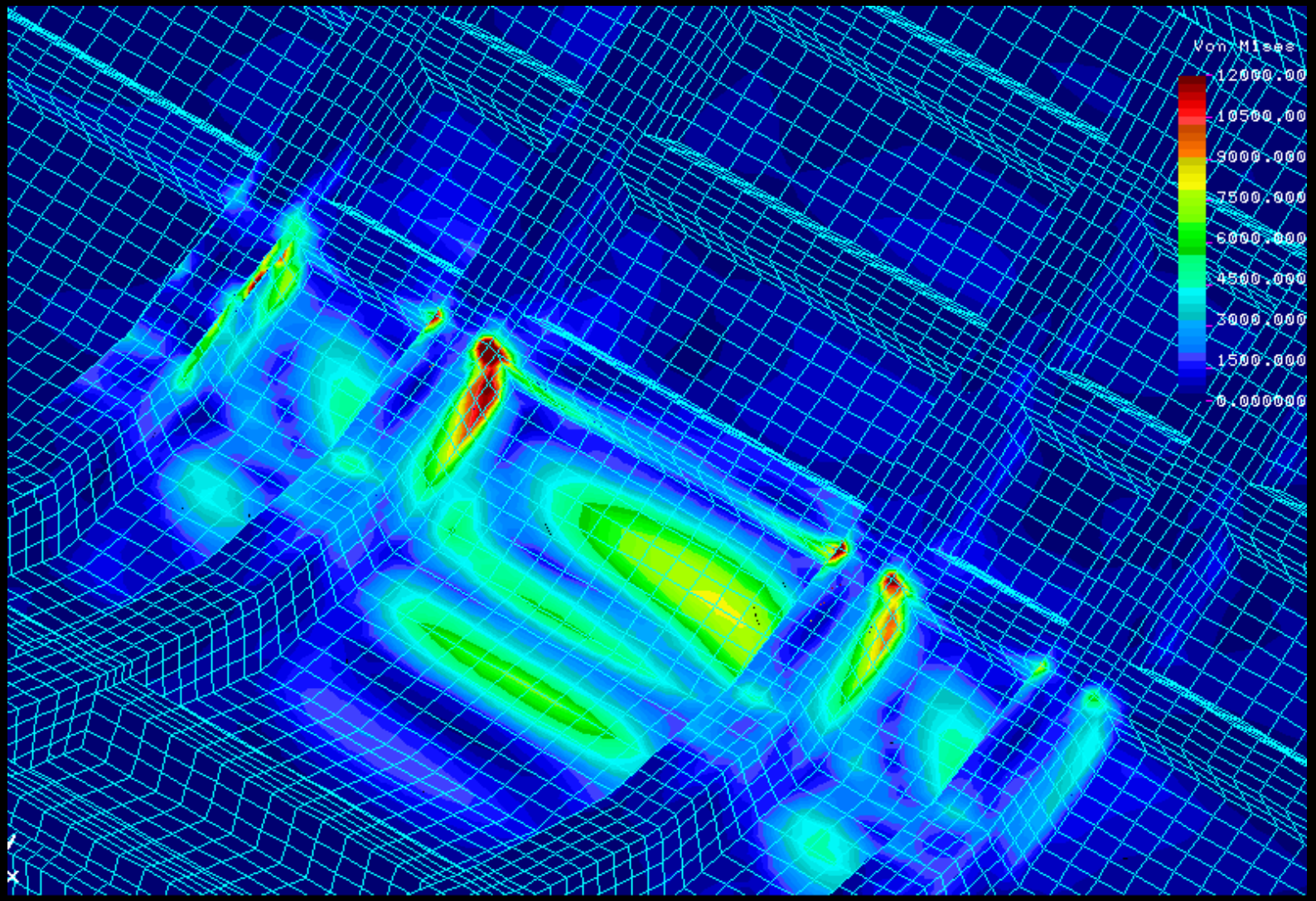
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LC3-AL- AMI- 45 Ply Tab and Side Wall Stress



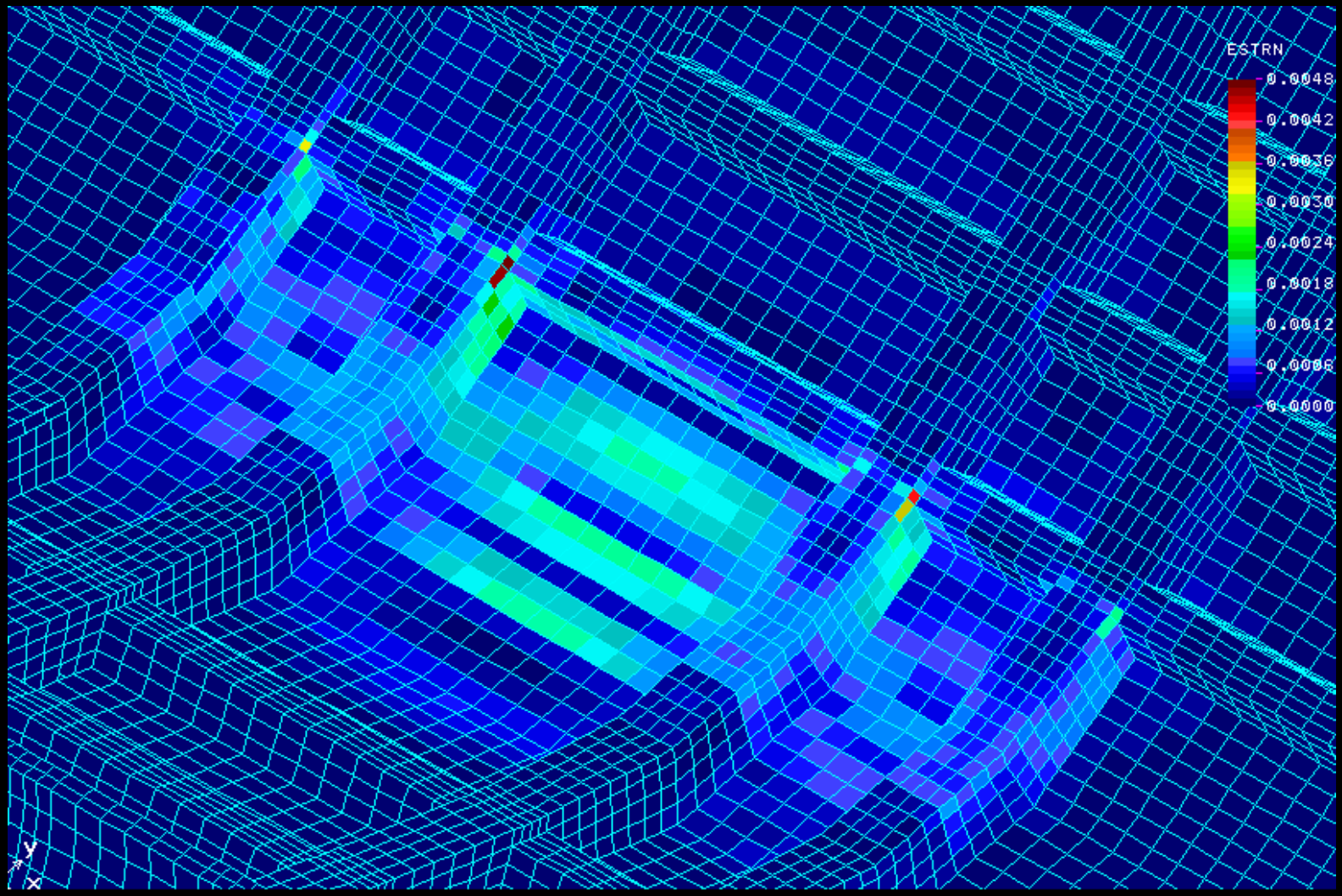
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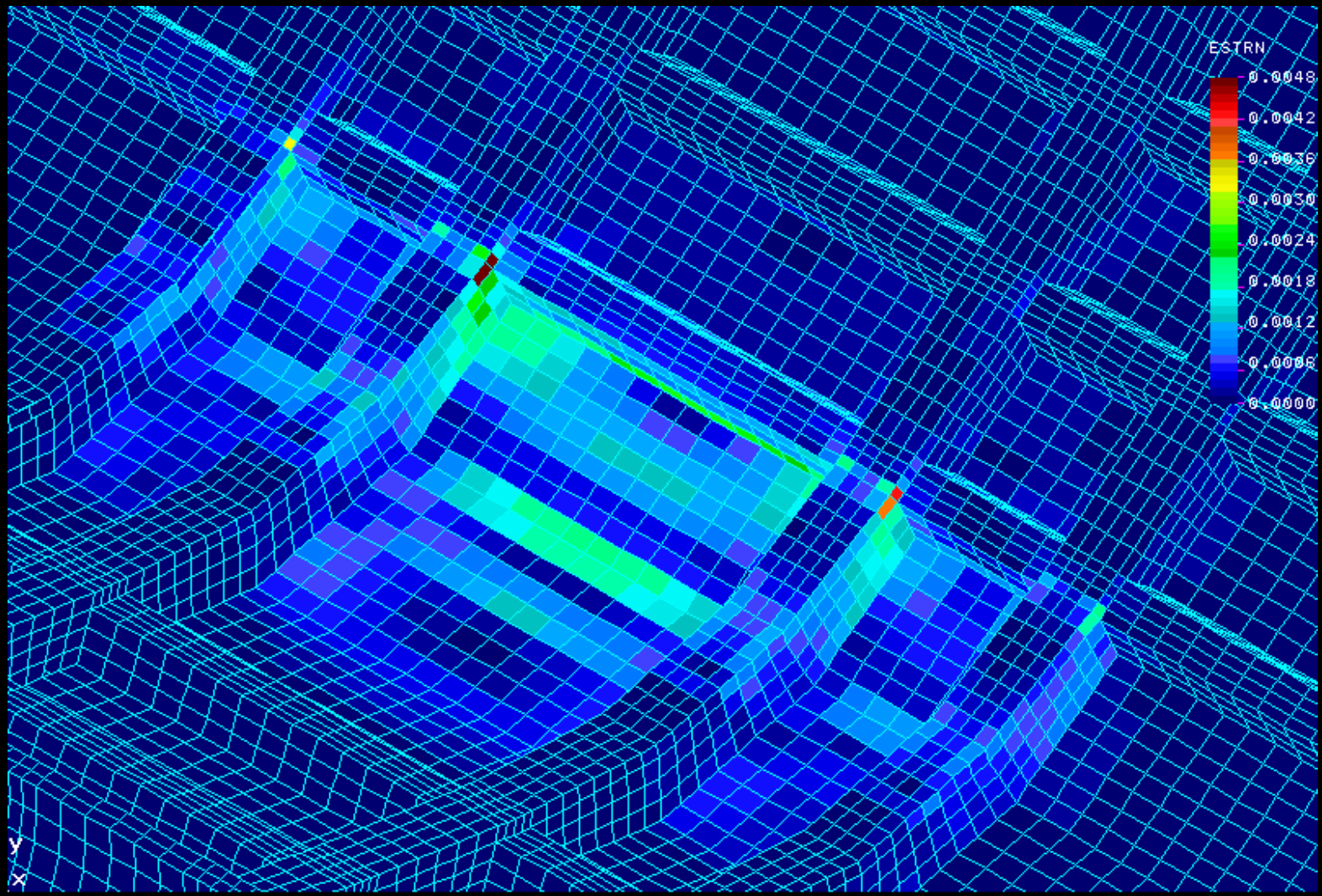
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LC3 - AL – AMI - Inside Surface Strain



LC3 – AL – AMI - Outside Surface Strain



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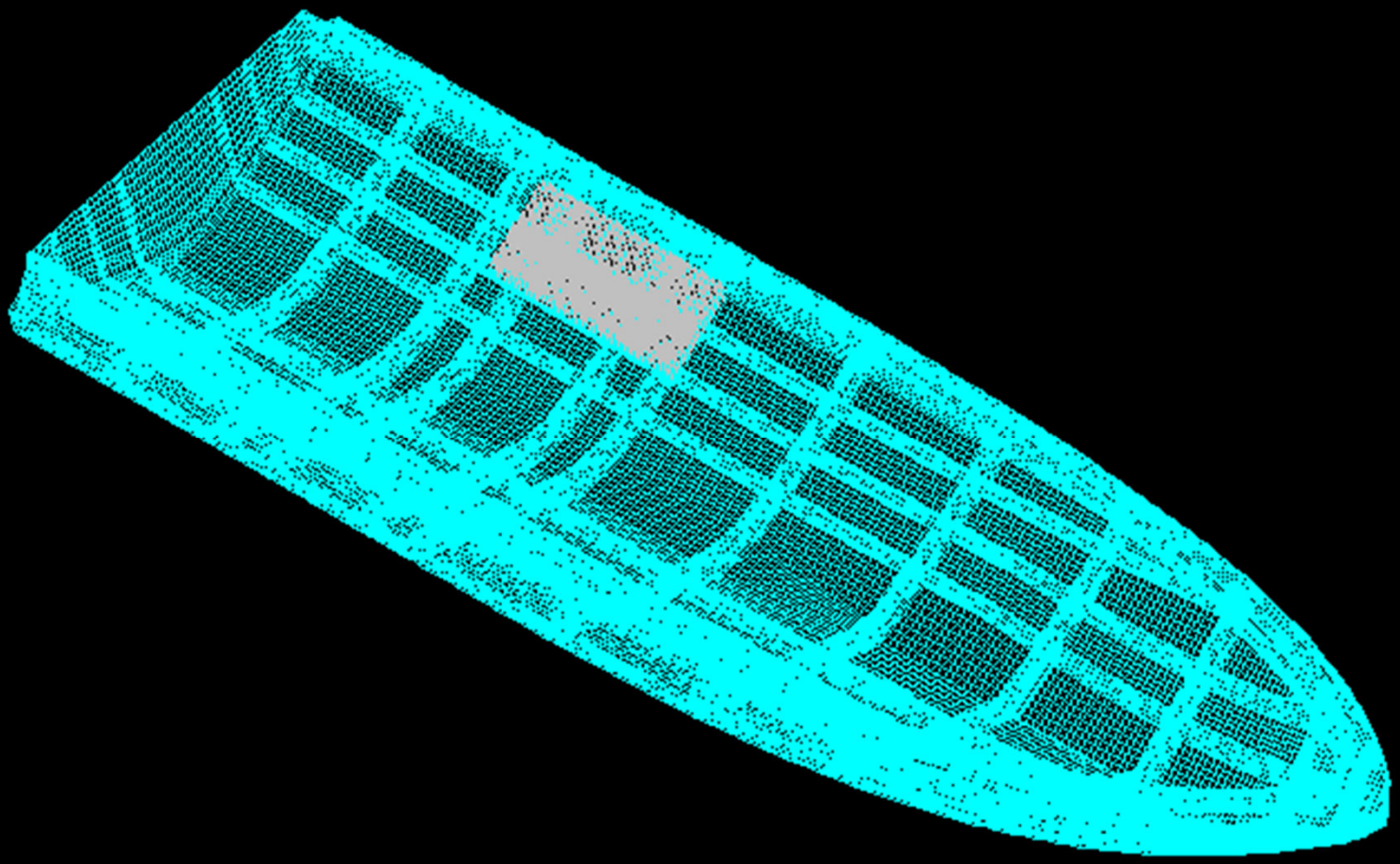
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LC3 – AI – AMI - Summary

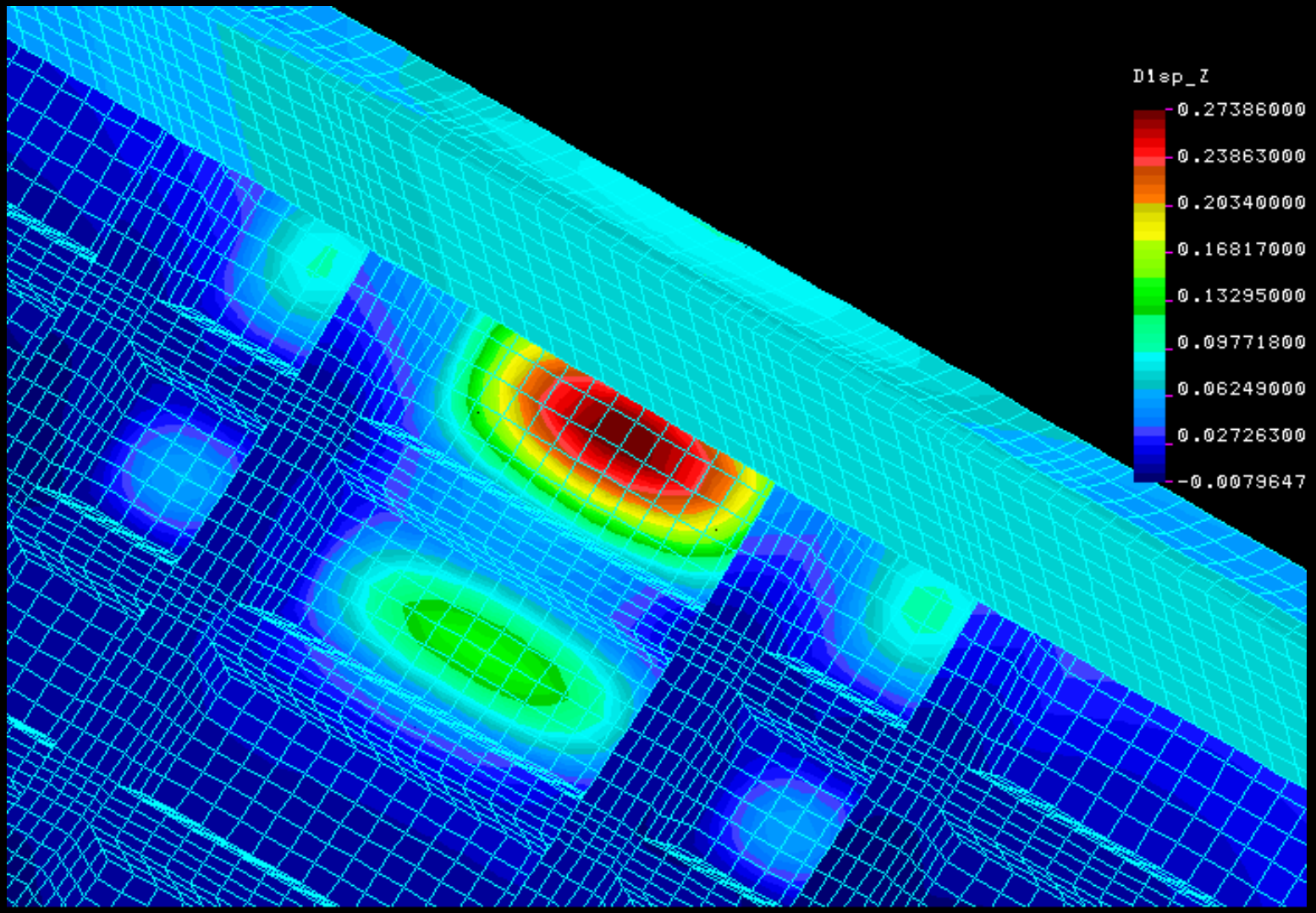
- Hull range of deflection to 0.21 in.
- Maximum Hull strain 0.0018 in/in
- Maximum Hull stress 5,500 psi
- Maximum framing strain 0.0024
- Maximum framing stress 4,000 psi

LC4 – AL - AMO-10 psi Pressure Load



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LC4-AL - AMO- Z Hull Displacement



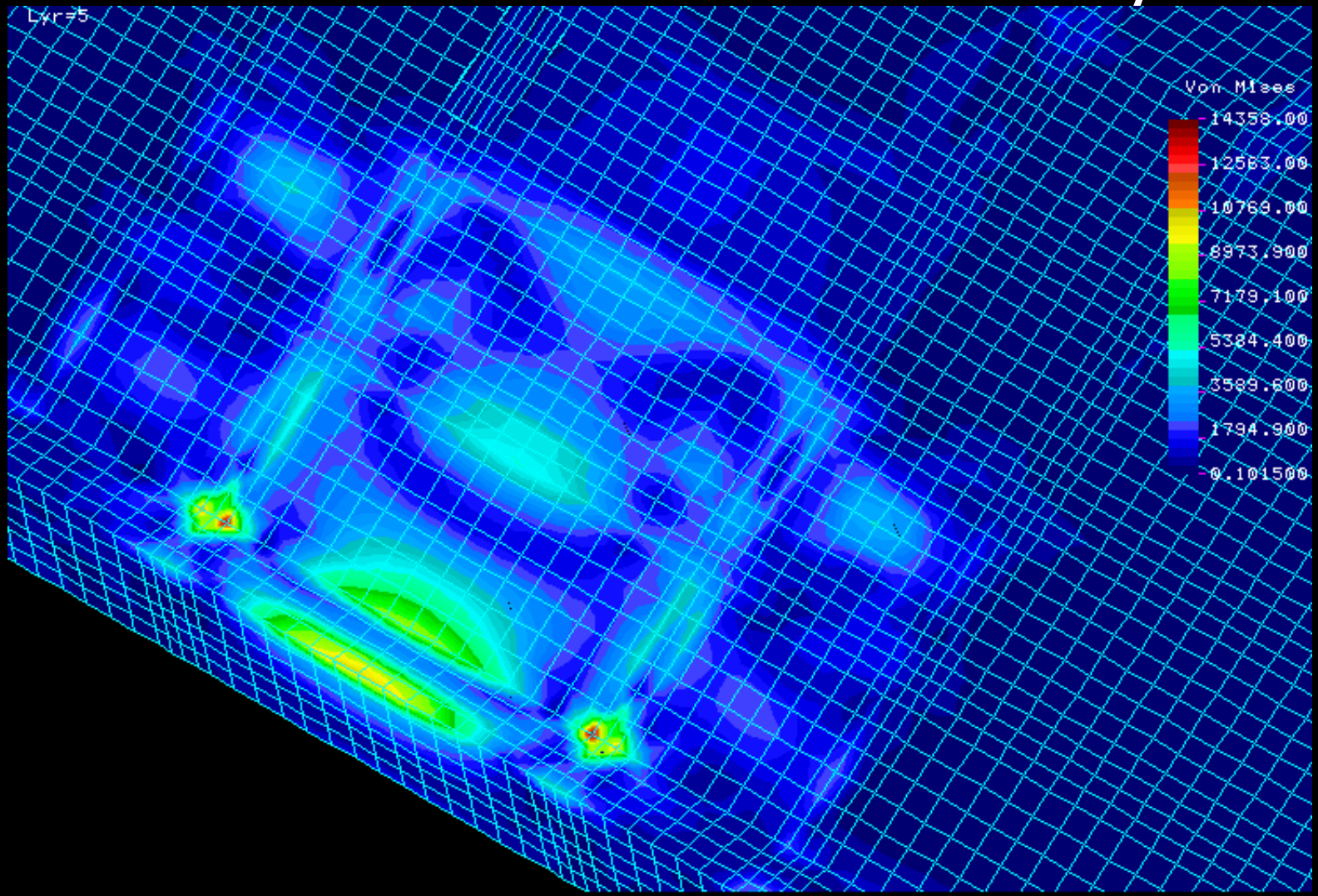
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LC4-AL- AMO- Transverse Carbon Ply Stress



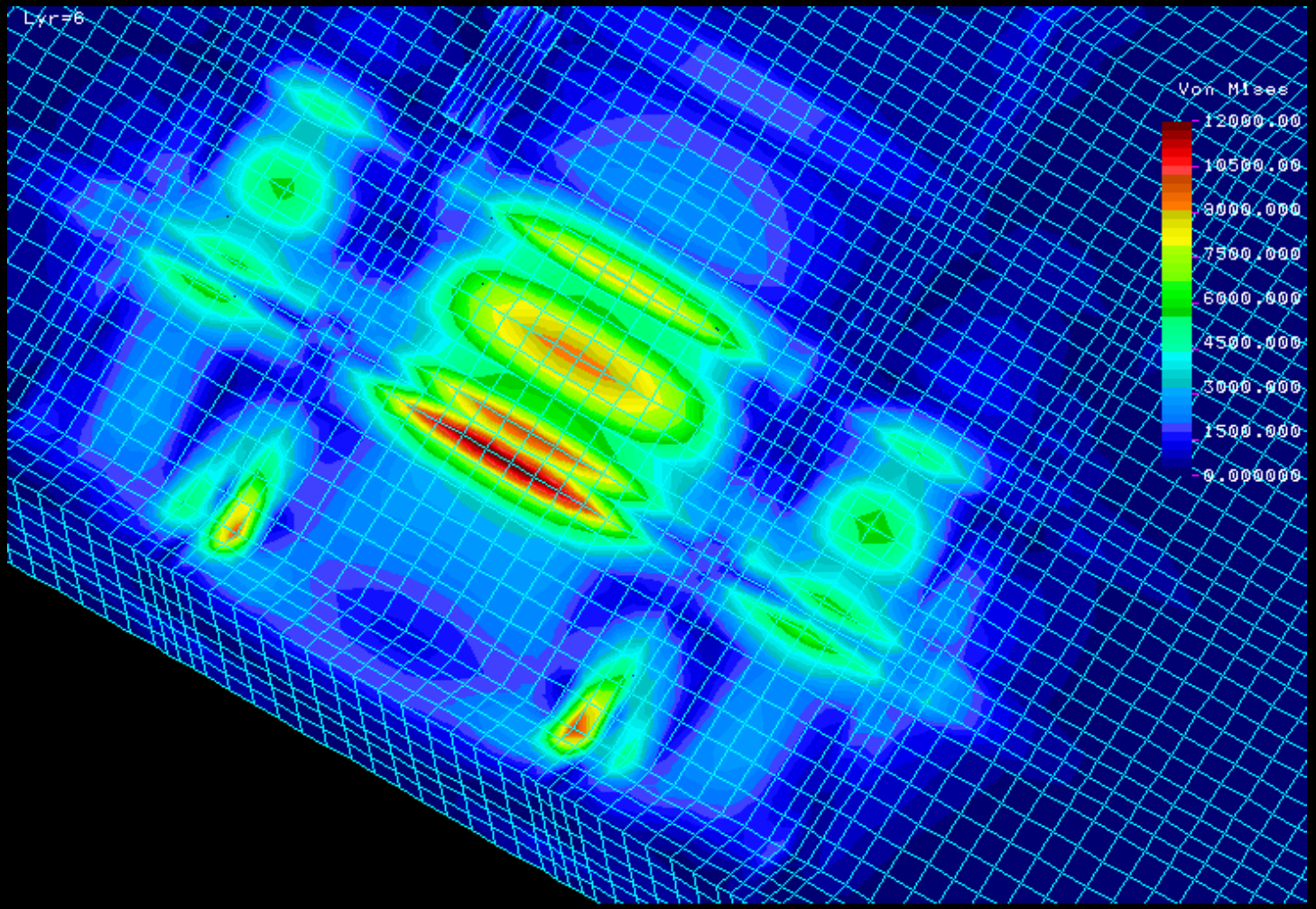
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LC4-AL-AMO-Longitudinal Carbon Ply Stress



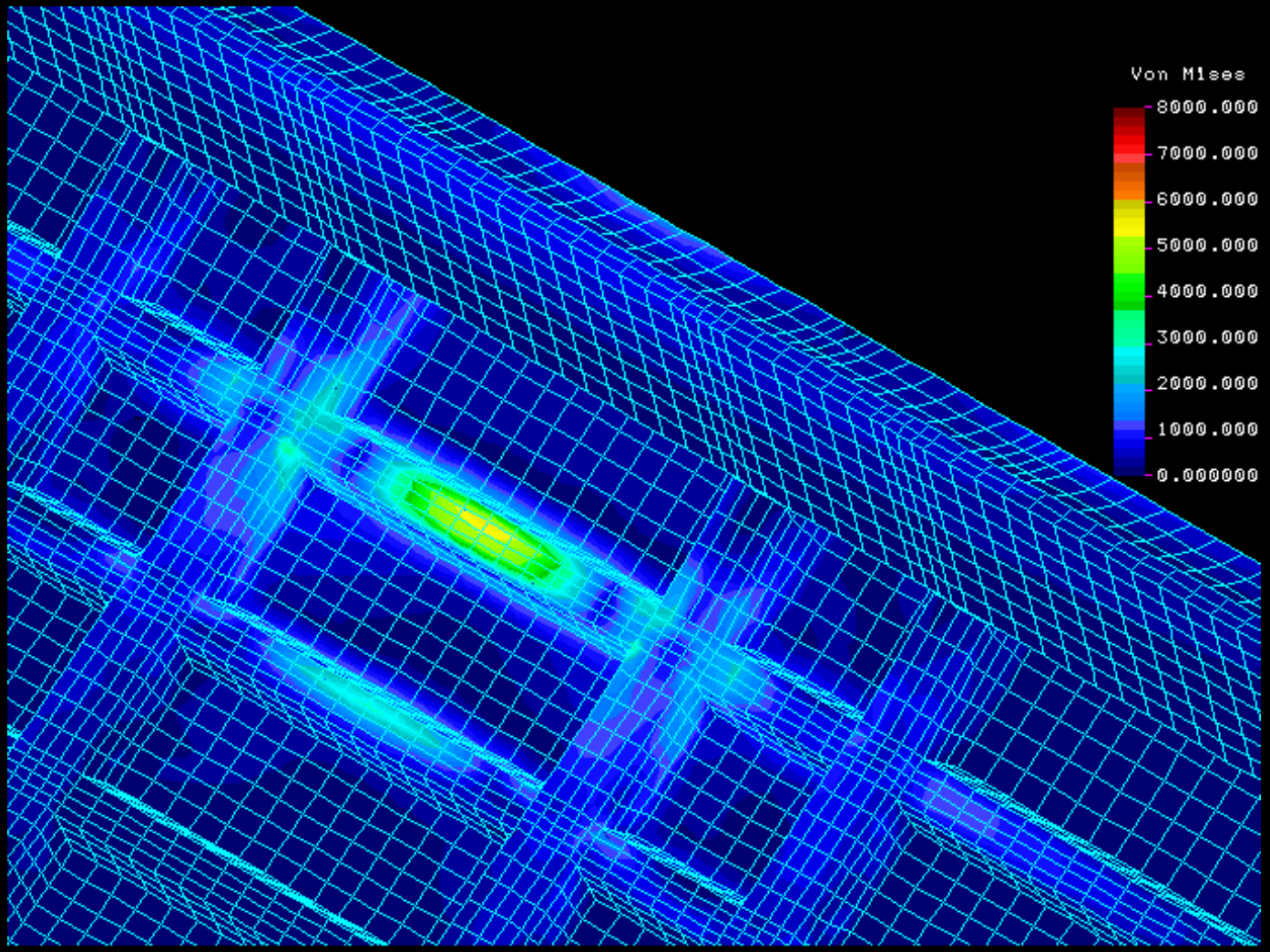
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LC4-AL- AMO-Longitudinal Stringer Cap Stress



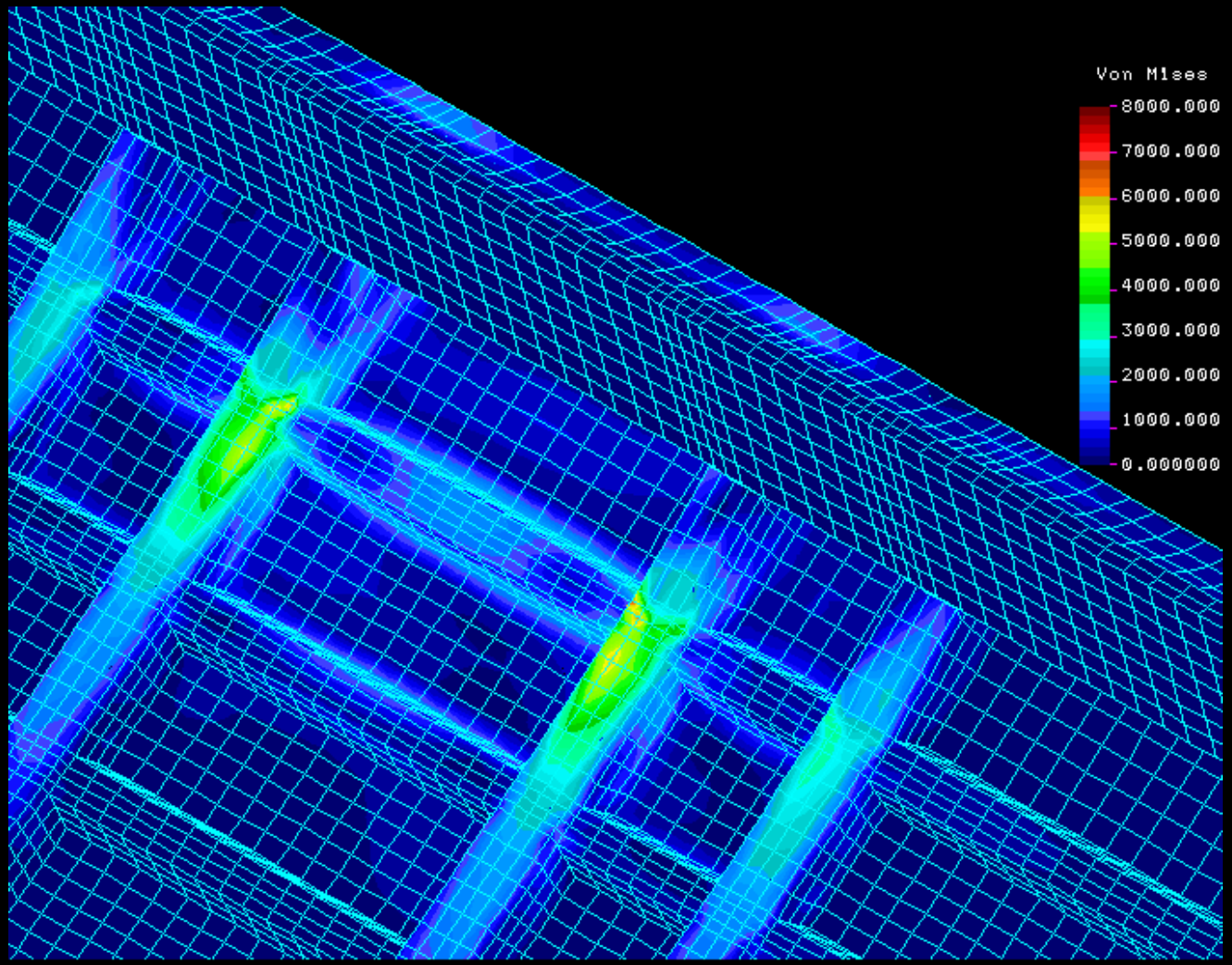
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LC4-AL - AMO- Transverse Frame Cap Stress



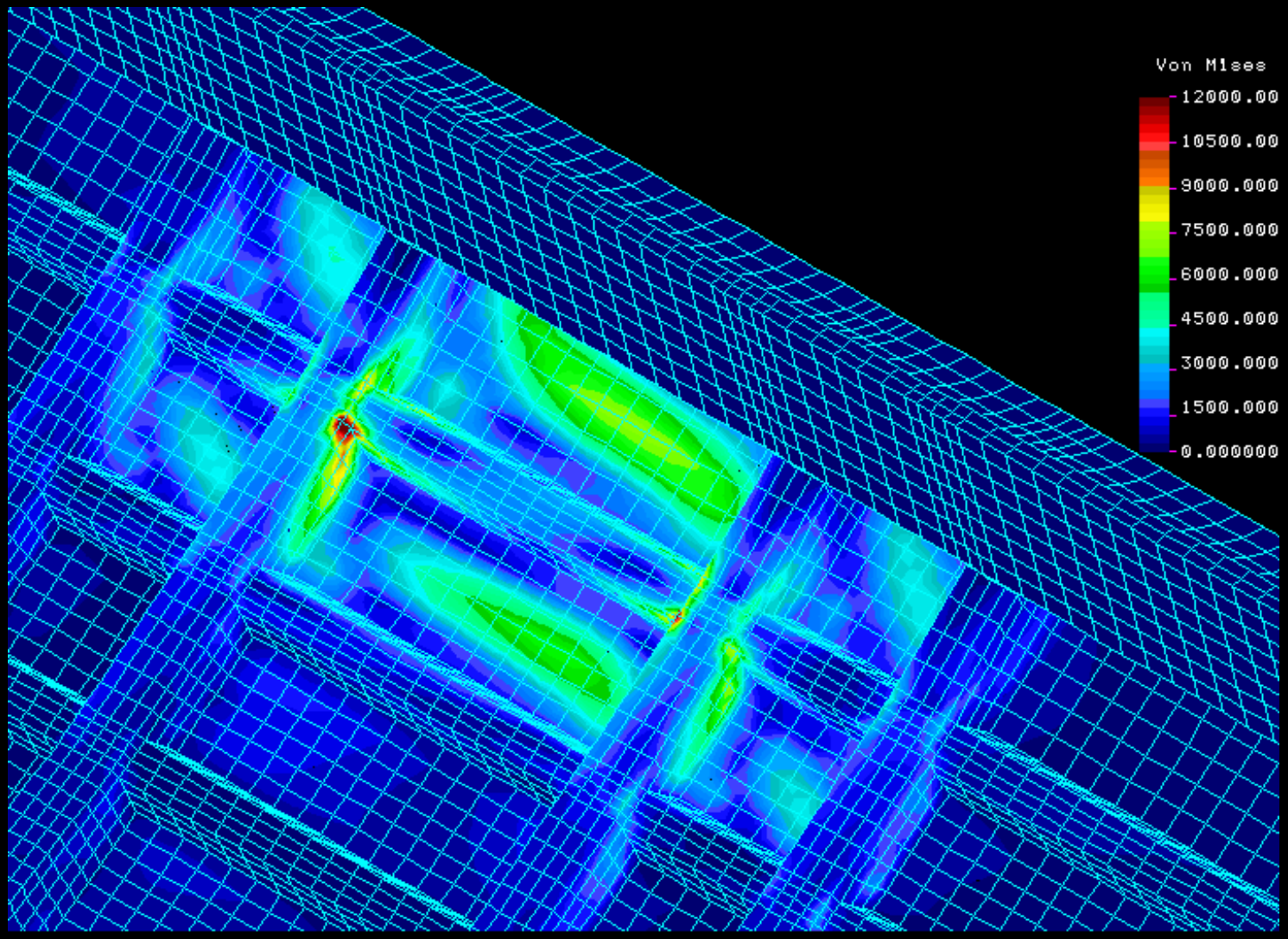
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LC4-AL - AMO- 45 Ply Tab and Side Wall Stress



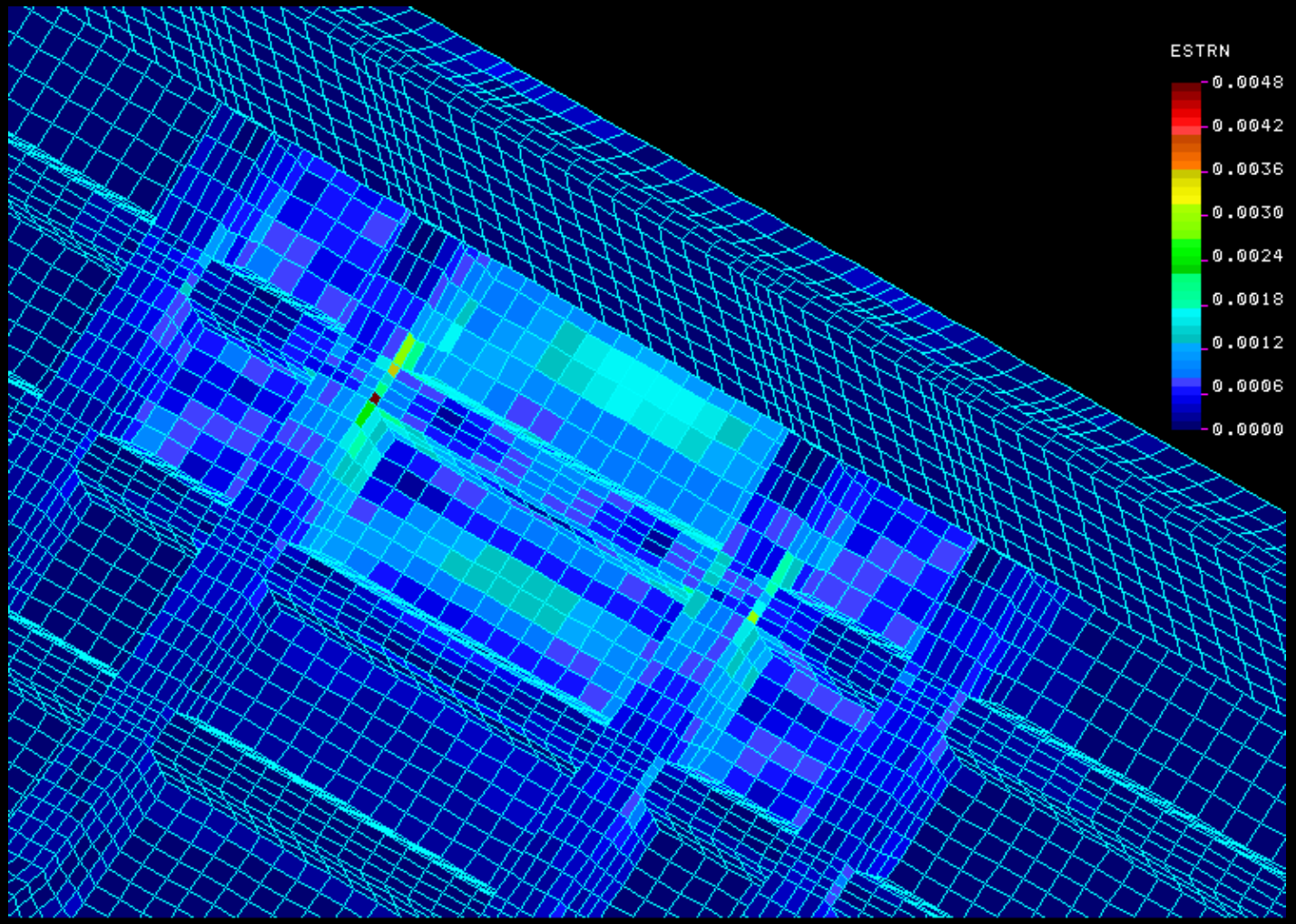
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LC4-AL - AMO- Inside Surface Strain



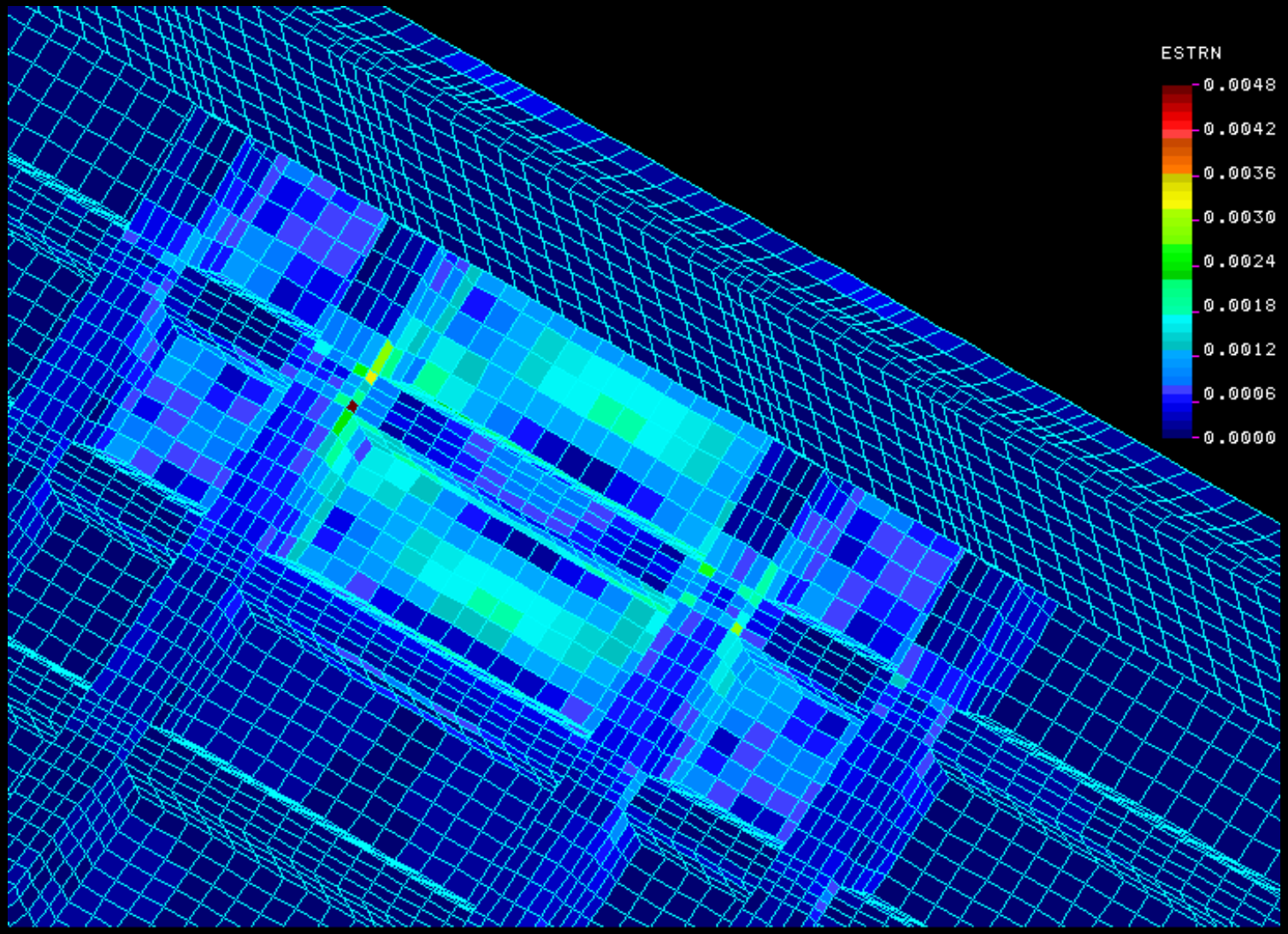
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LC4-AL - AMO- Outside Surface Strain



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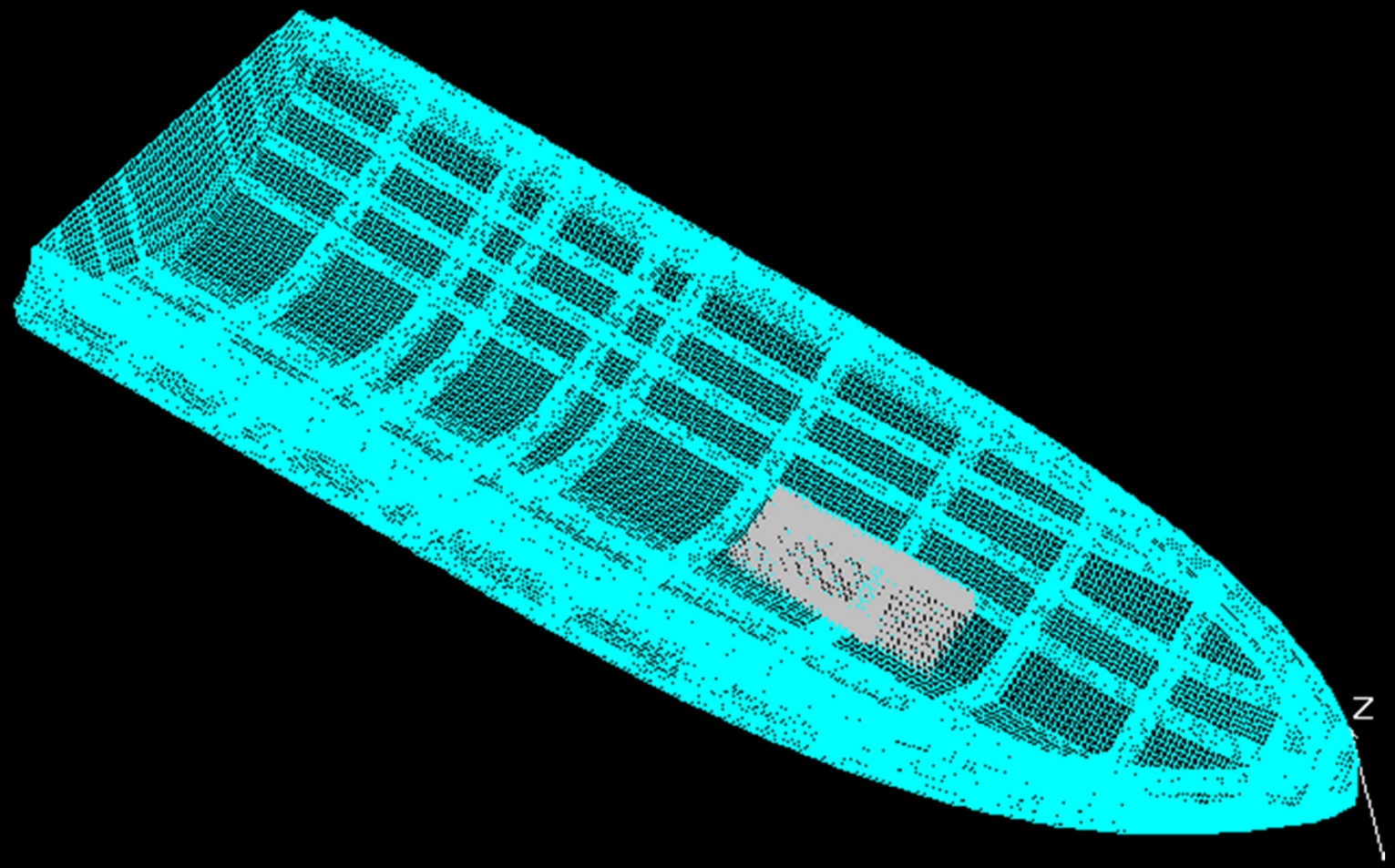
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LC4 – AL - AMO- Summary

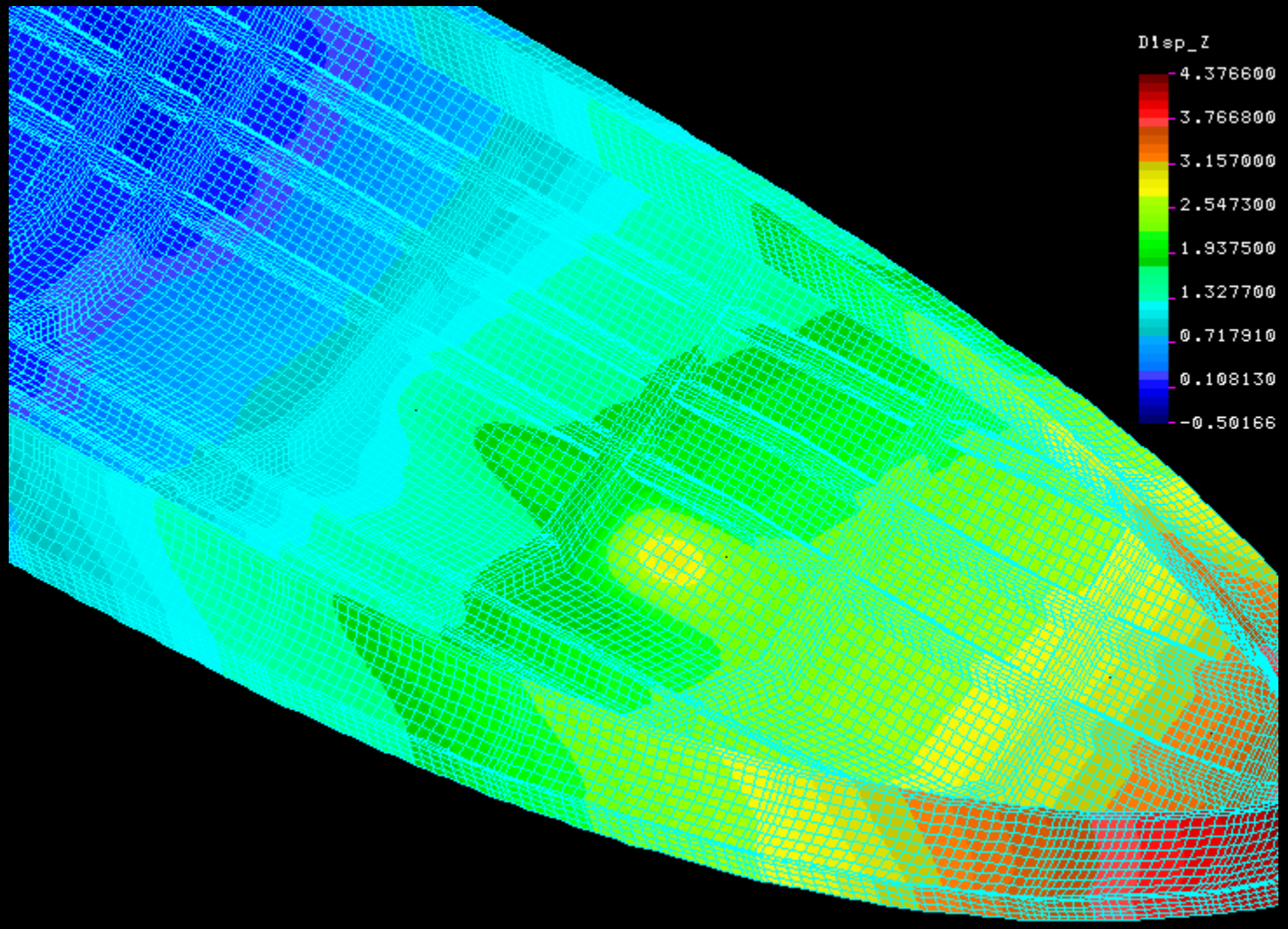
- Hull range of deflection to 0.28 in.
- Maximum Hull strain 0.0018 in/in
- Maximum Hull stress 12,000 psi
- Maximum framing strain 0.0003
- Maximum framing stress 5,500 psi

LC5 - AL - FMI-10 psi Pressure Load



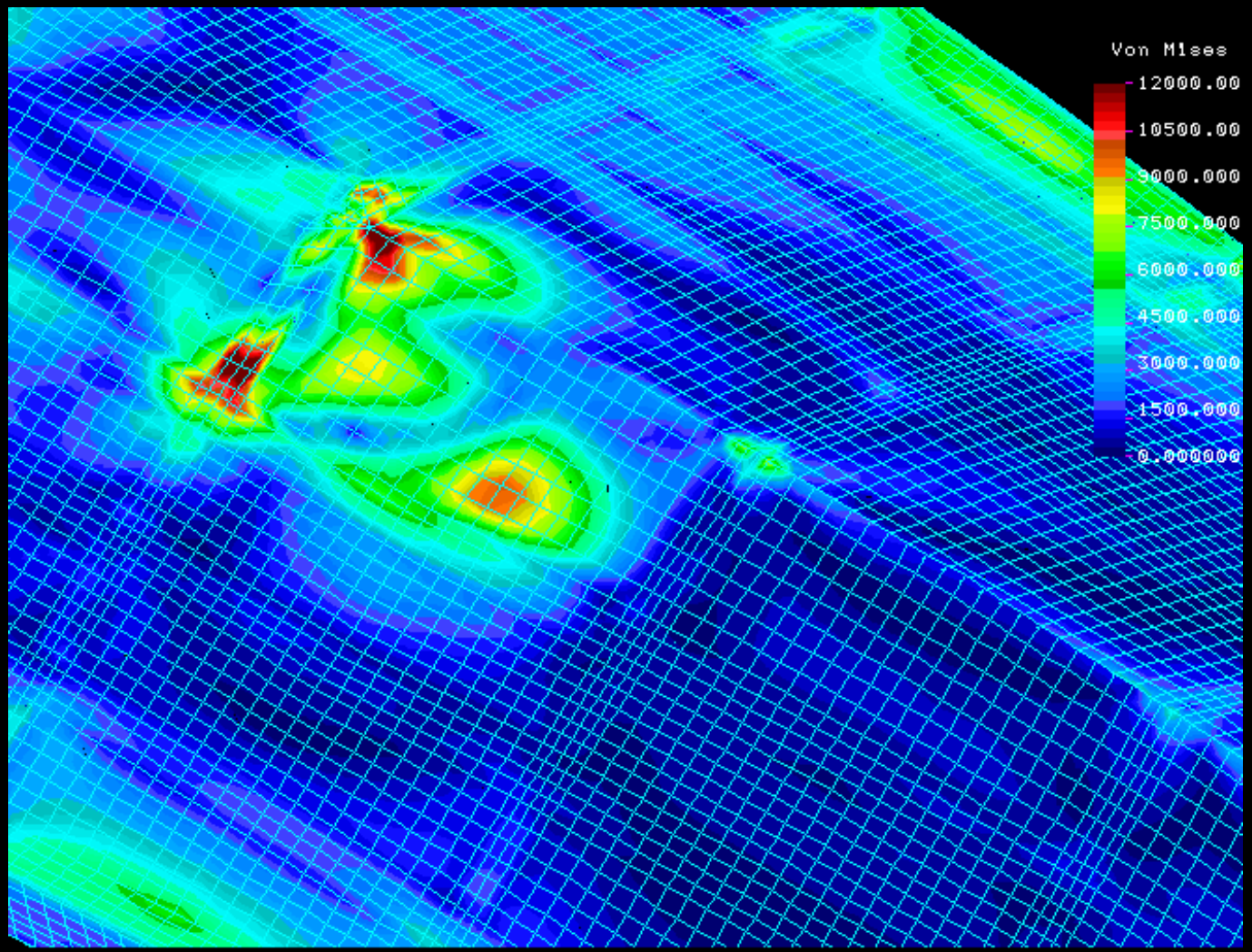
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LC5 – AL - FMI- Z Hull Displacement



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LC5 - AL- FMI - Transverse Carbon Ply Stress



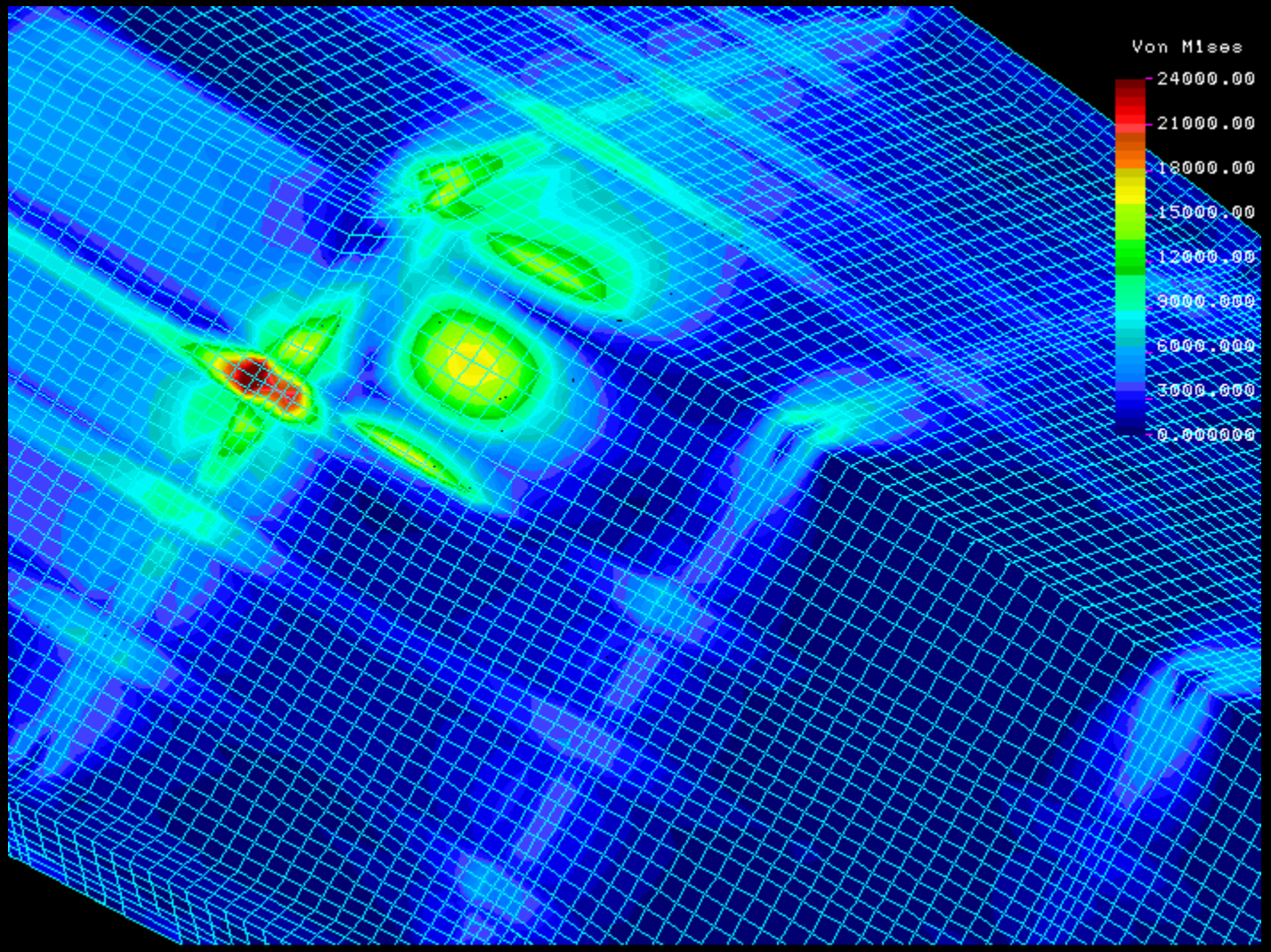
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LC5-AL- FMI- Longitudinal Carbon Ply Stress



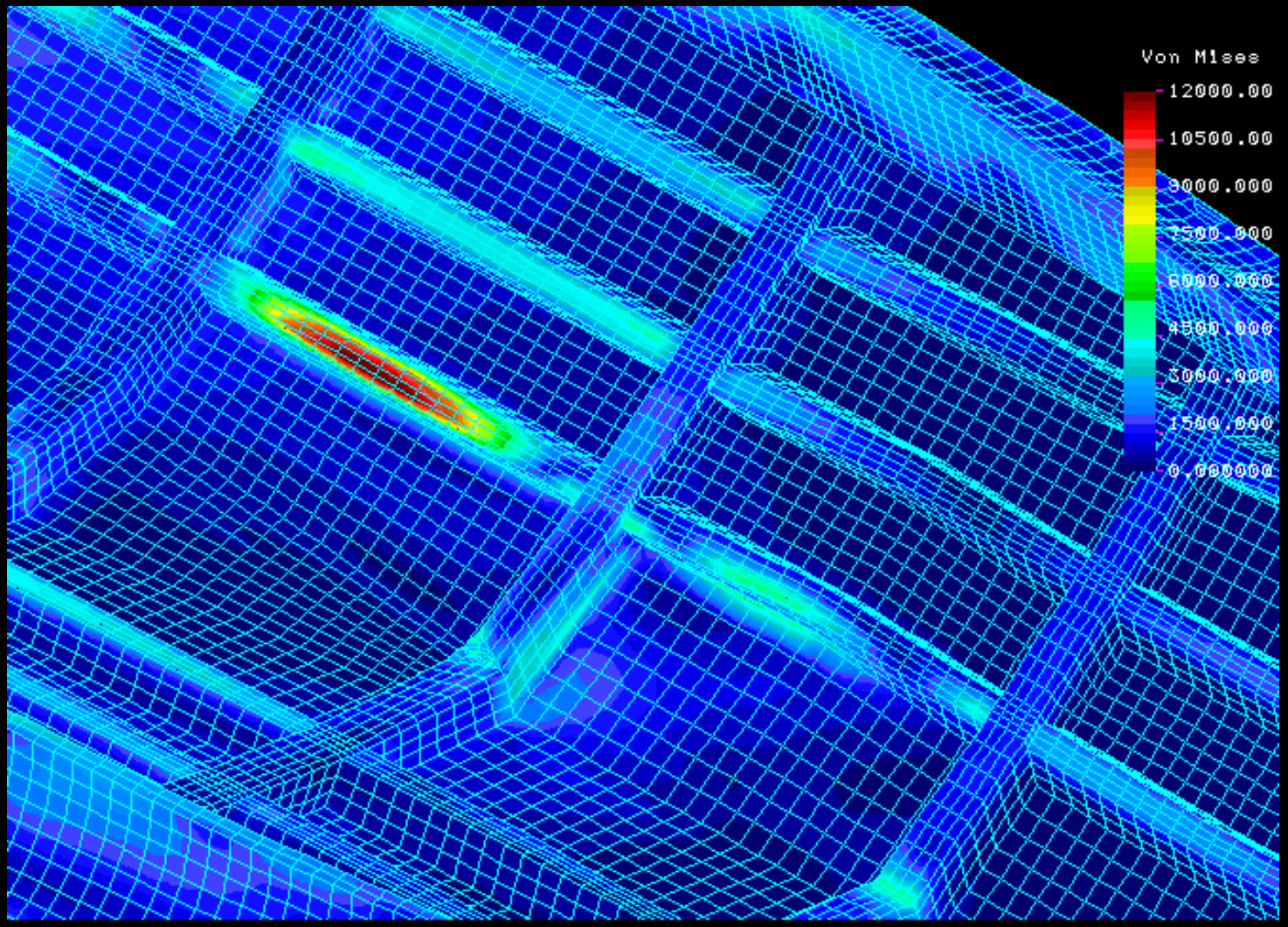
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LC5-AL - FMI-Longitudinal Stringer Cap Stress



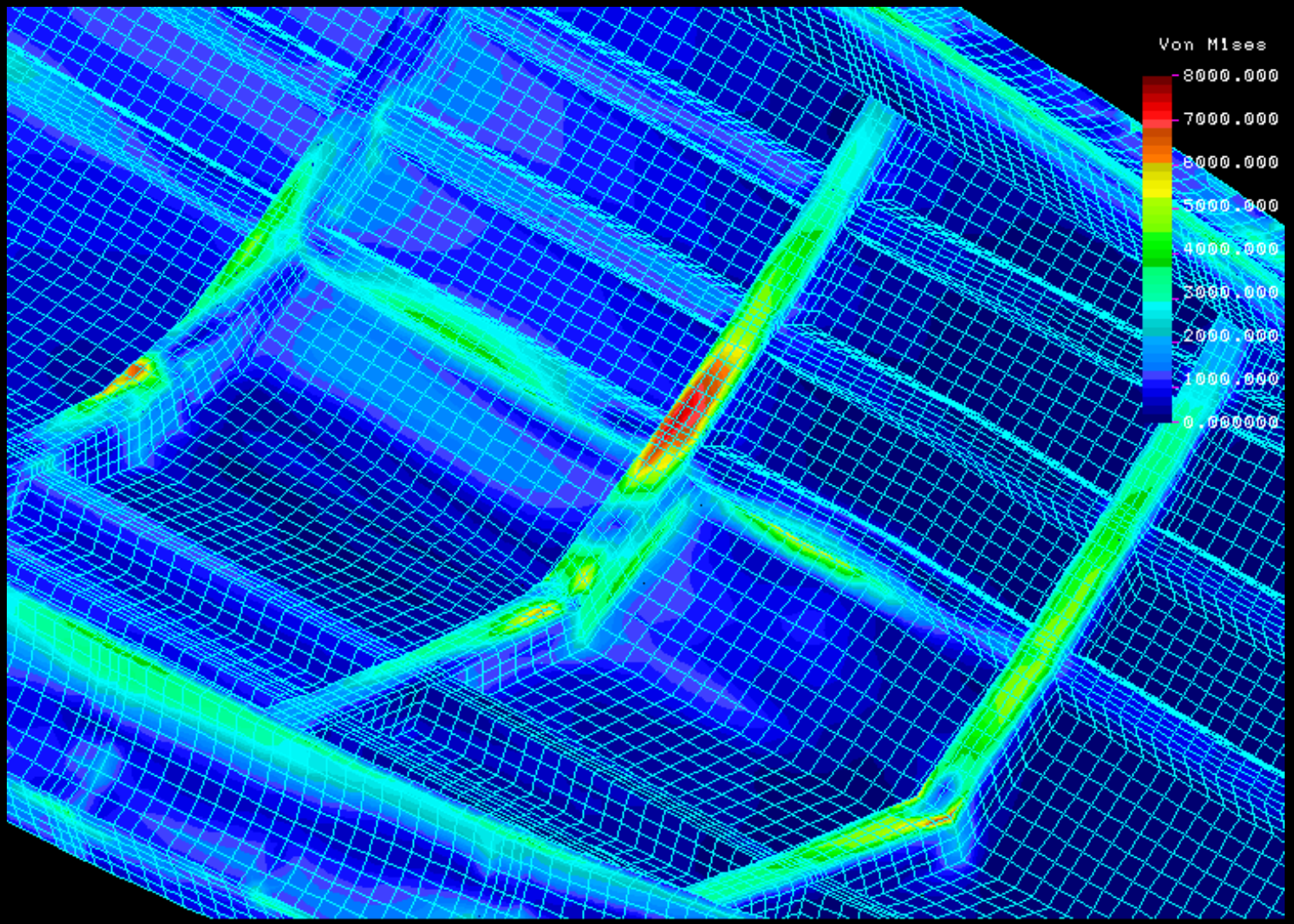
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LC5-AL- FMI- Transverse Frame Cap Stress



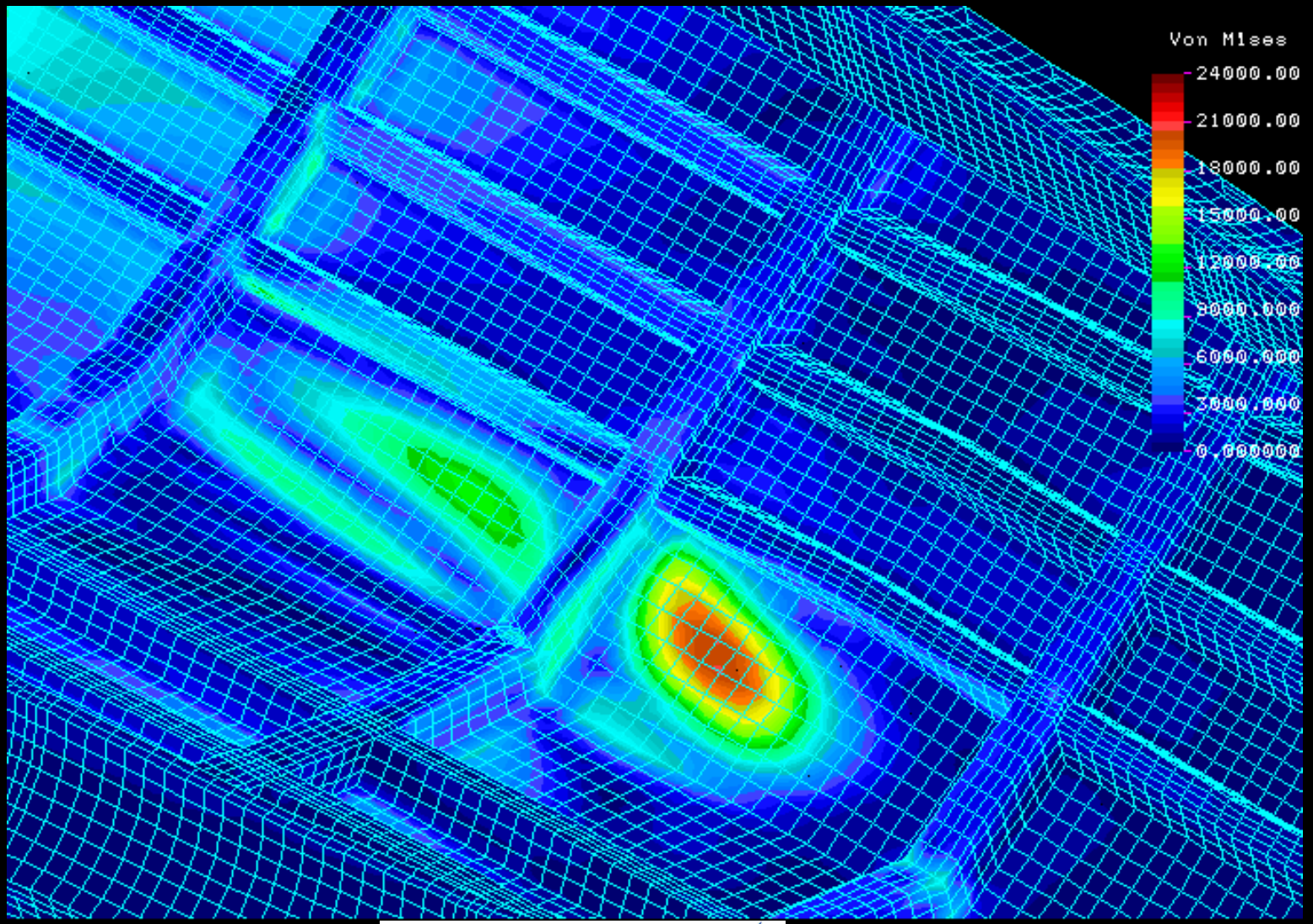
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LC5-AL-FMI- 45 Ply Tab and Side Wall Stress



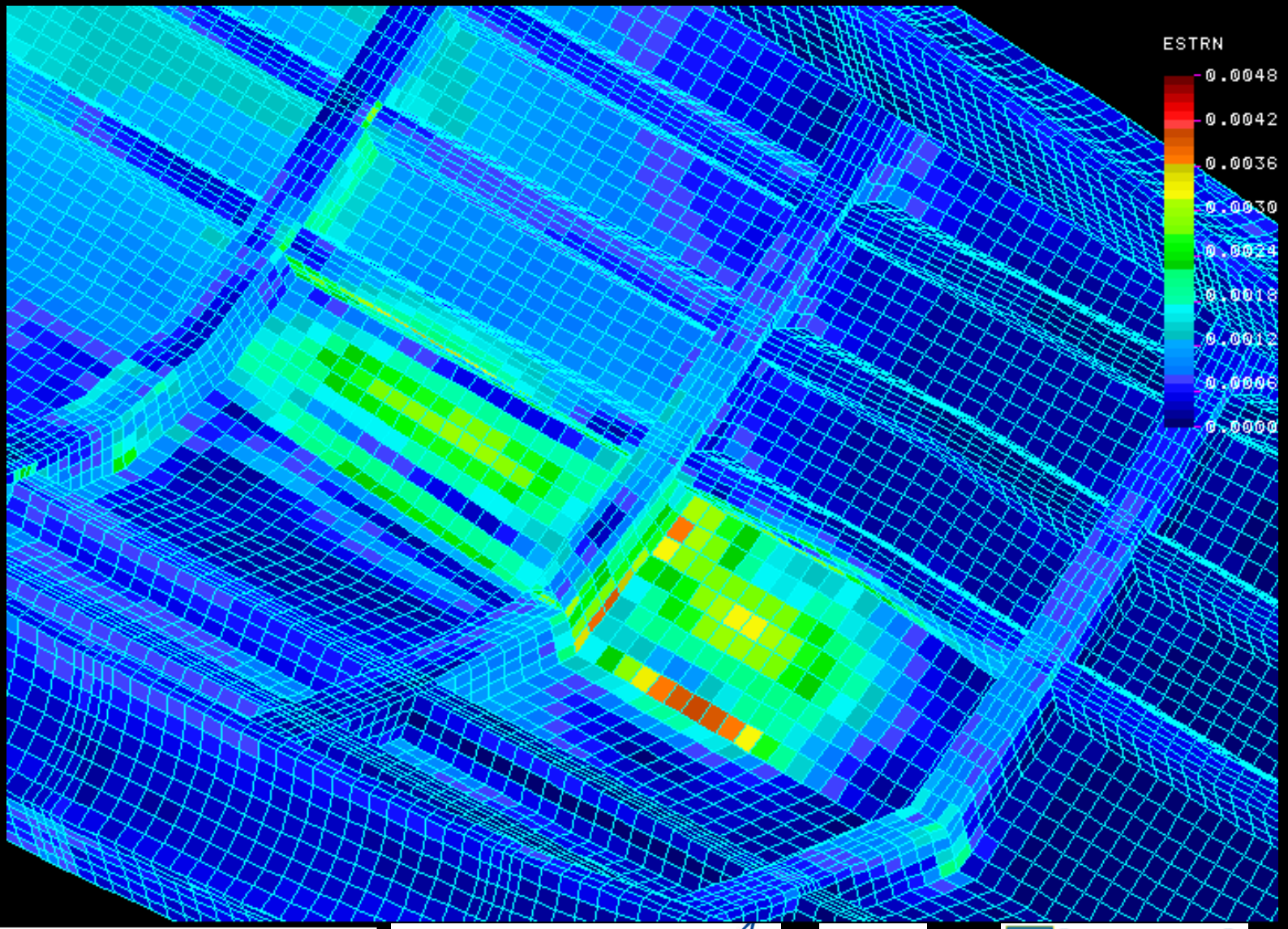
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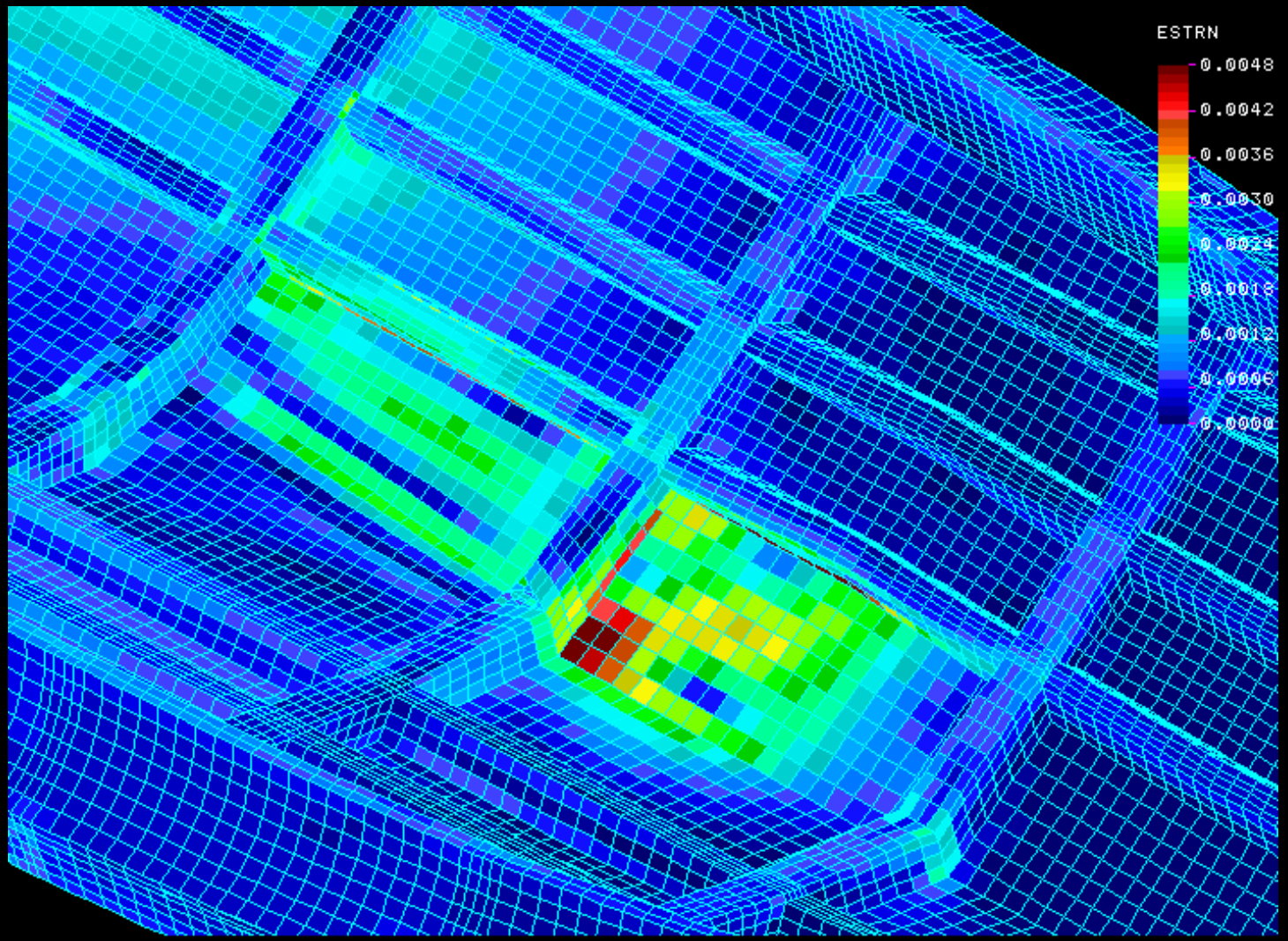
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LC5 – AL – FMI - Inside Surface Strain



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LC5 - AL – FMI - Outside Surface Strain



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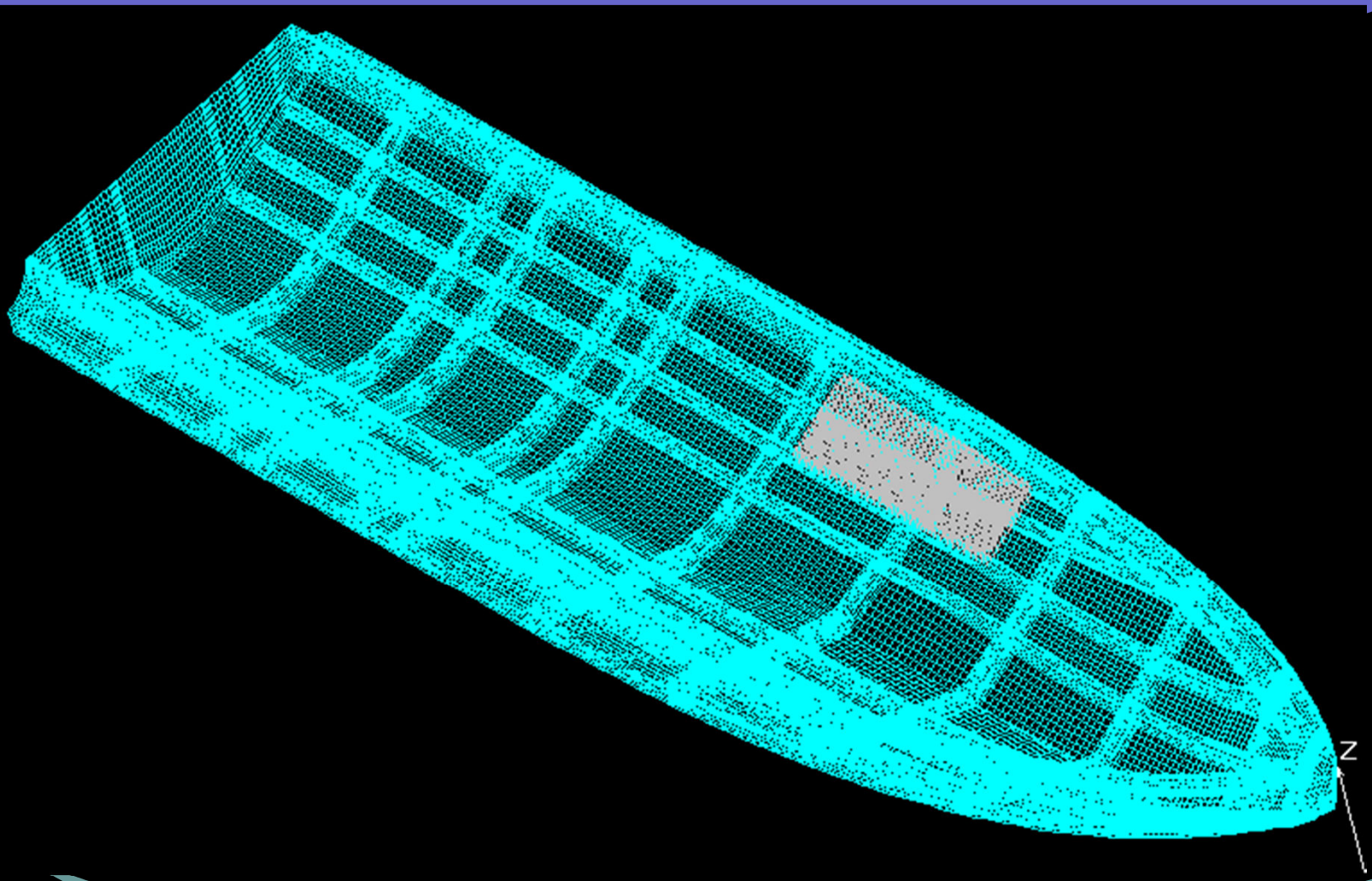
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LC5 - AL- FMI- Summary

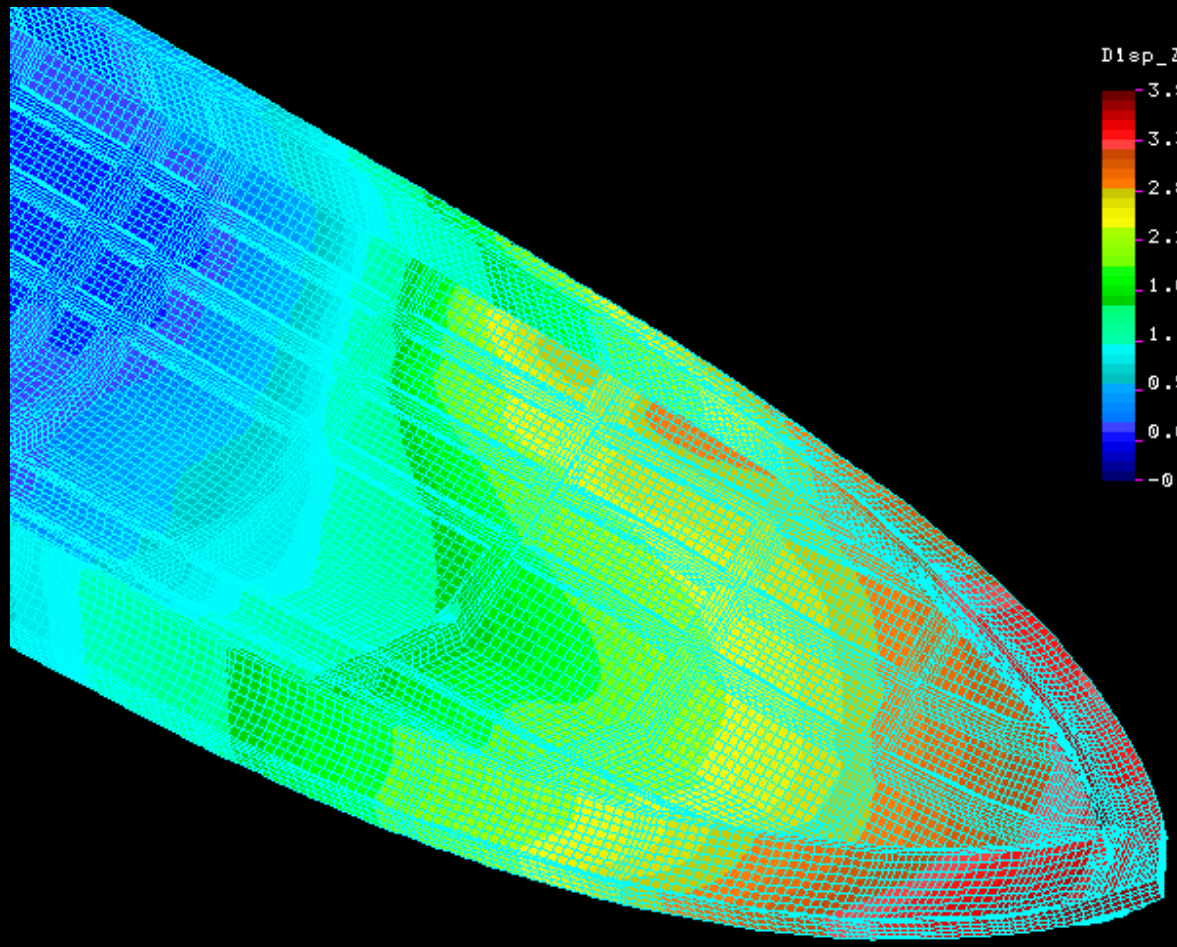
- Hull range of deflection to 4.88 in.
- Maximum Hull strain 0.0048 in/in
- Maximum Hull stress 24,000 psi
- Maximum framing strain 0.0036 in/in
- Maximum framing stress 12,000 psi

LC6 – AL - FM0-10 psi Pressure Load



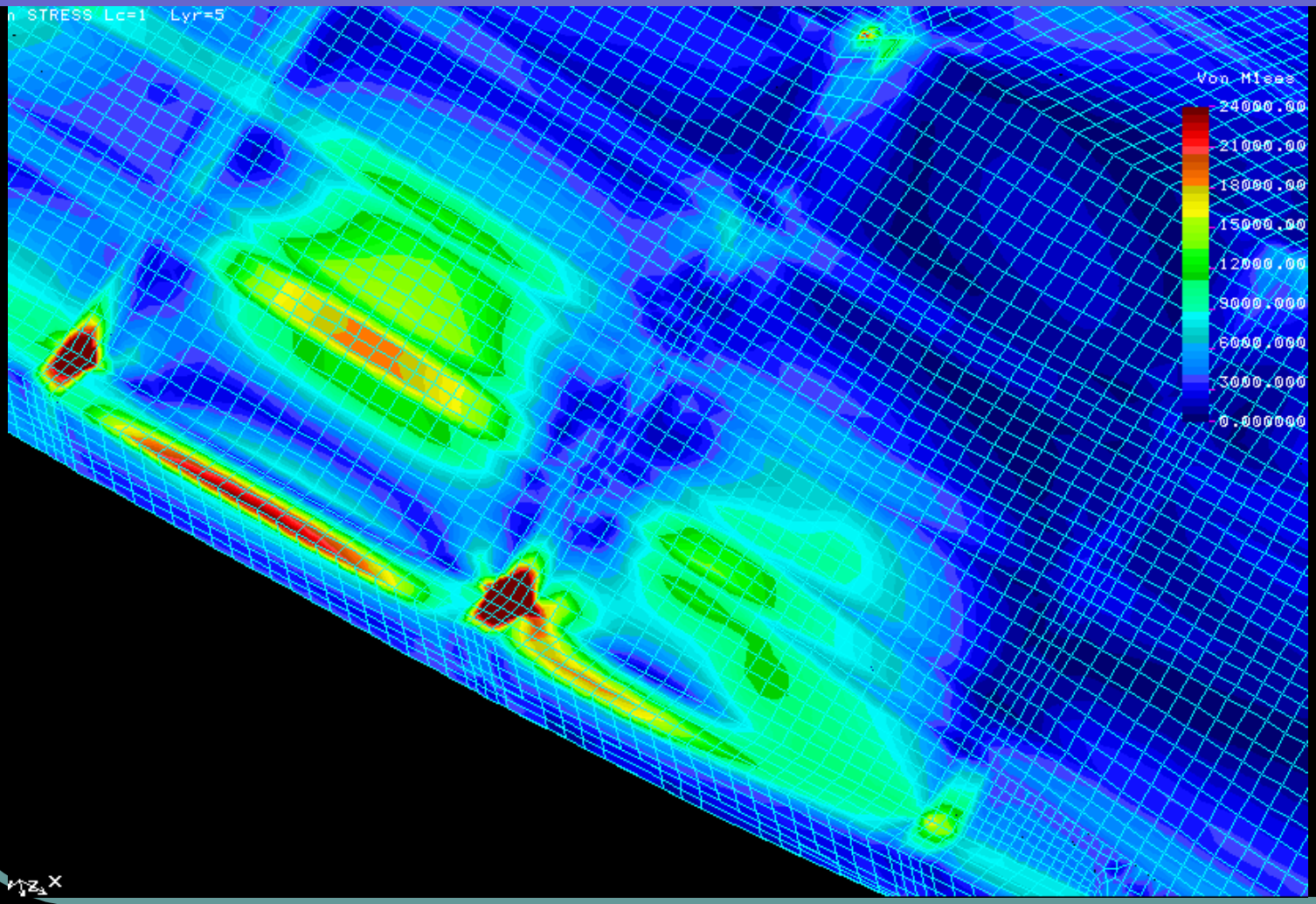
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LC6-AL - FM0- Z Hull Displacement



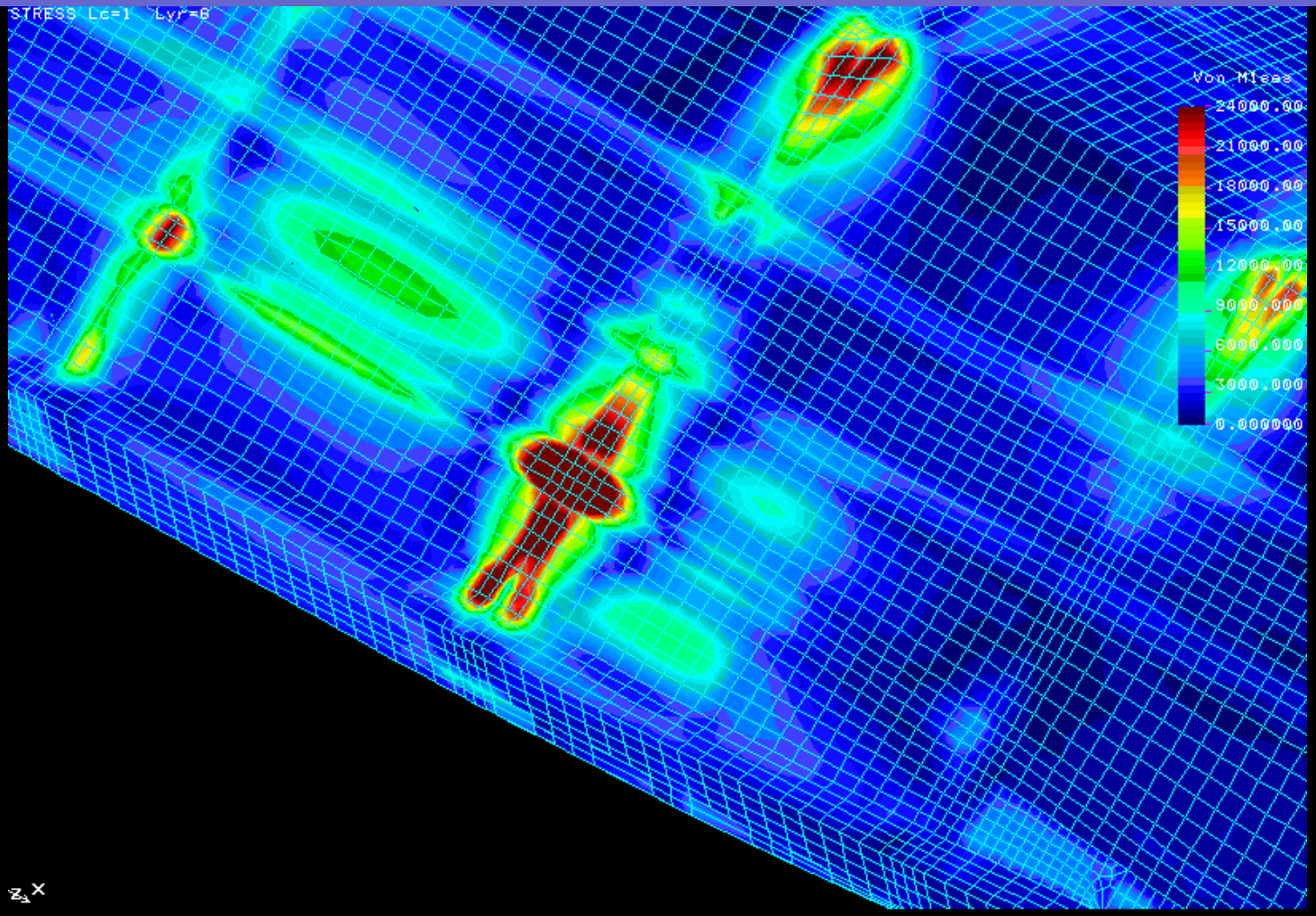
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LC6-AL FM0- Transverse Carbon Ply Stress

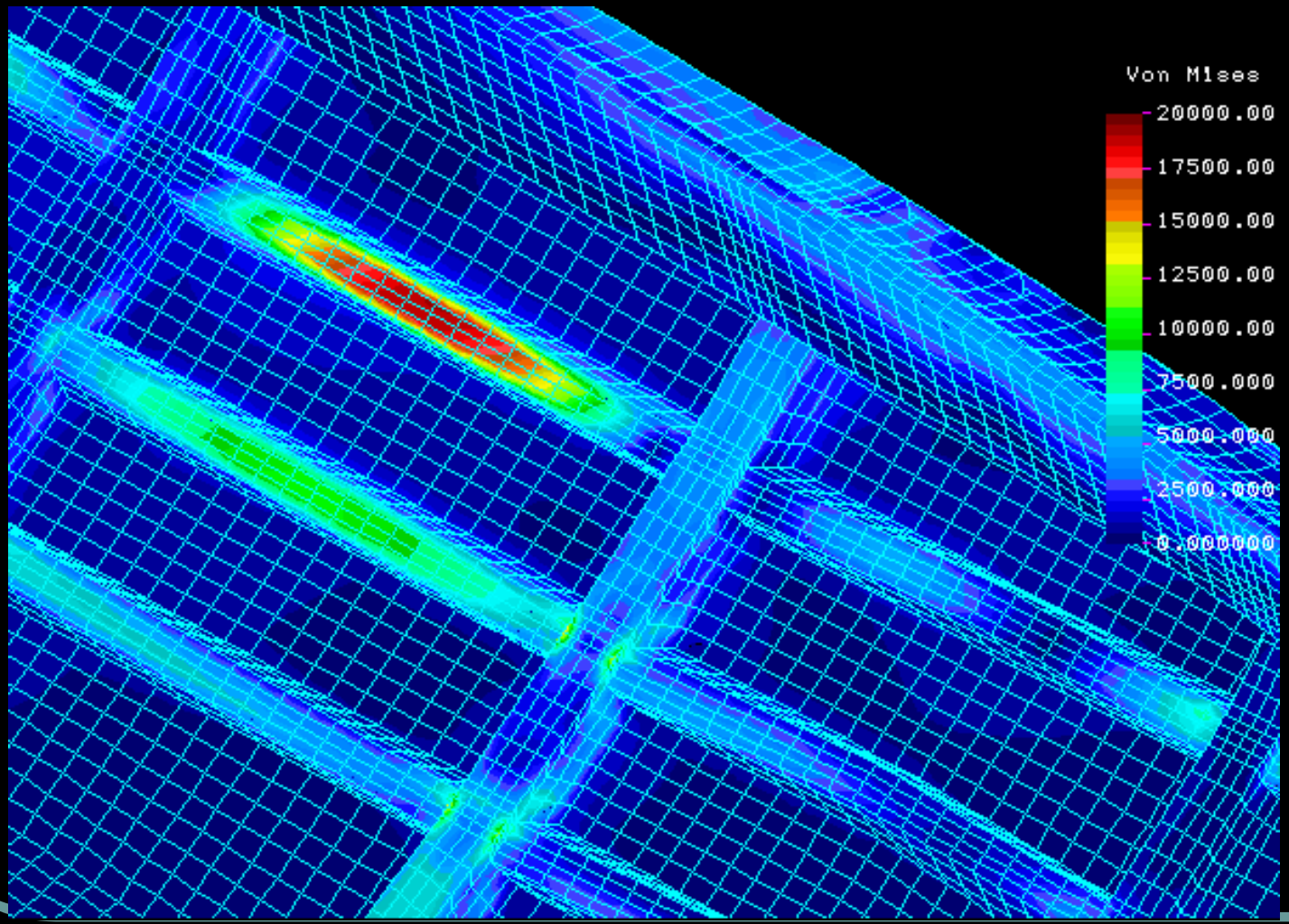


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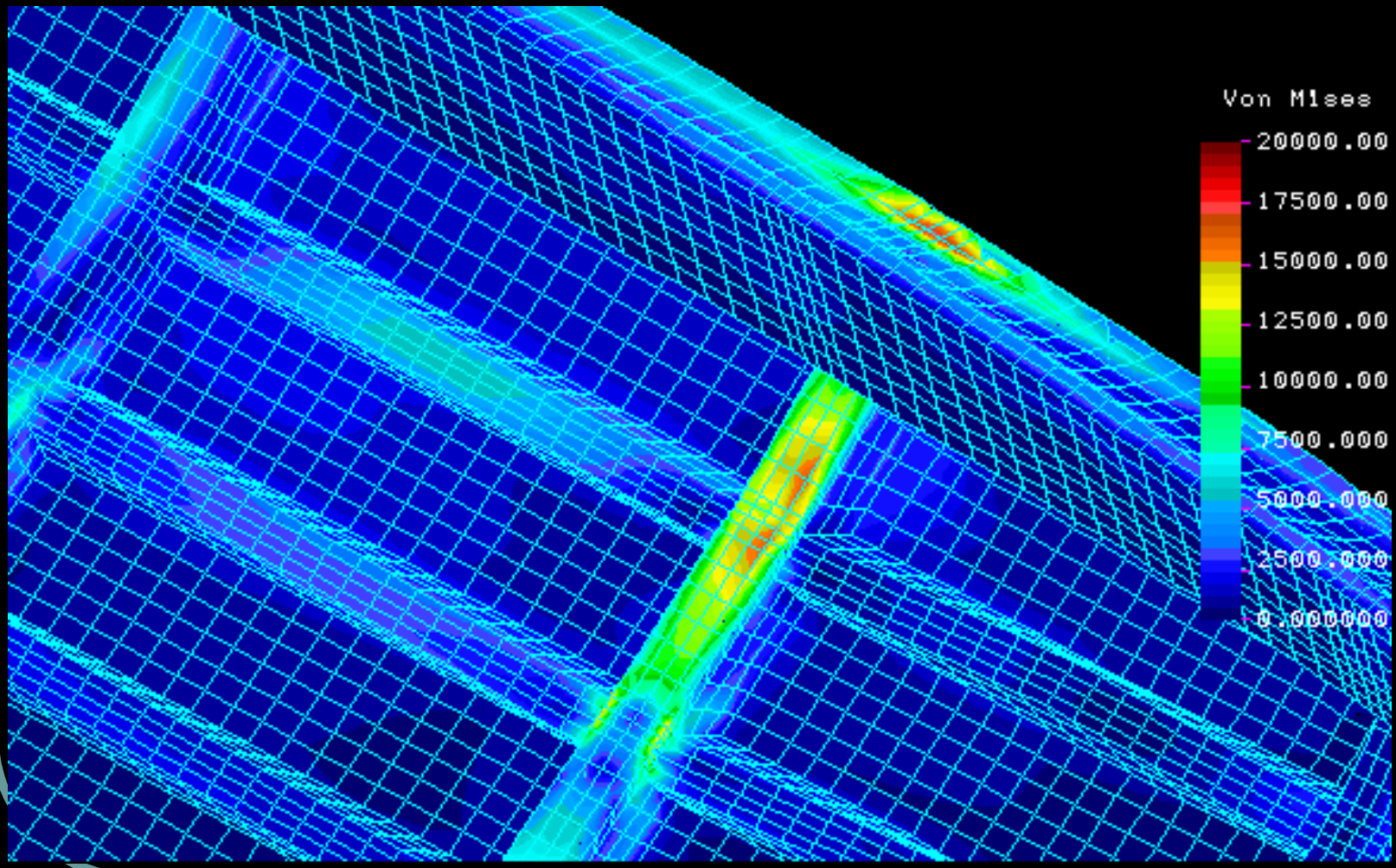
LC6-AL FM0- Longitudinal Carbon Ply Stress



LC6-AL - FMO-Longitudinal Stringer Cap Stress

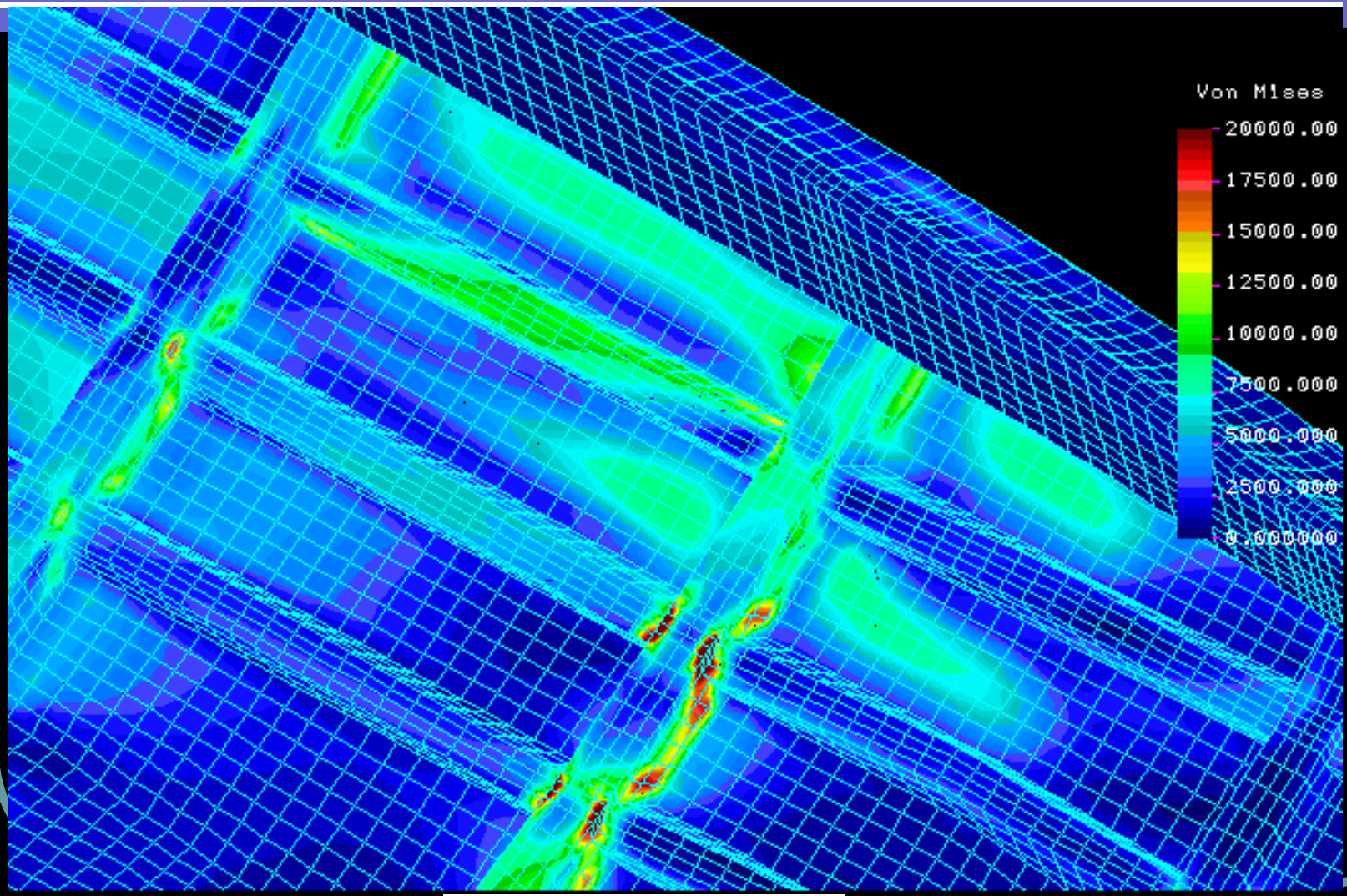


LC6-AL- FMO- Transverse Frame Cap Stress



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LC6-AL- FMO- 45 Ply Tab and Side Wall Stress



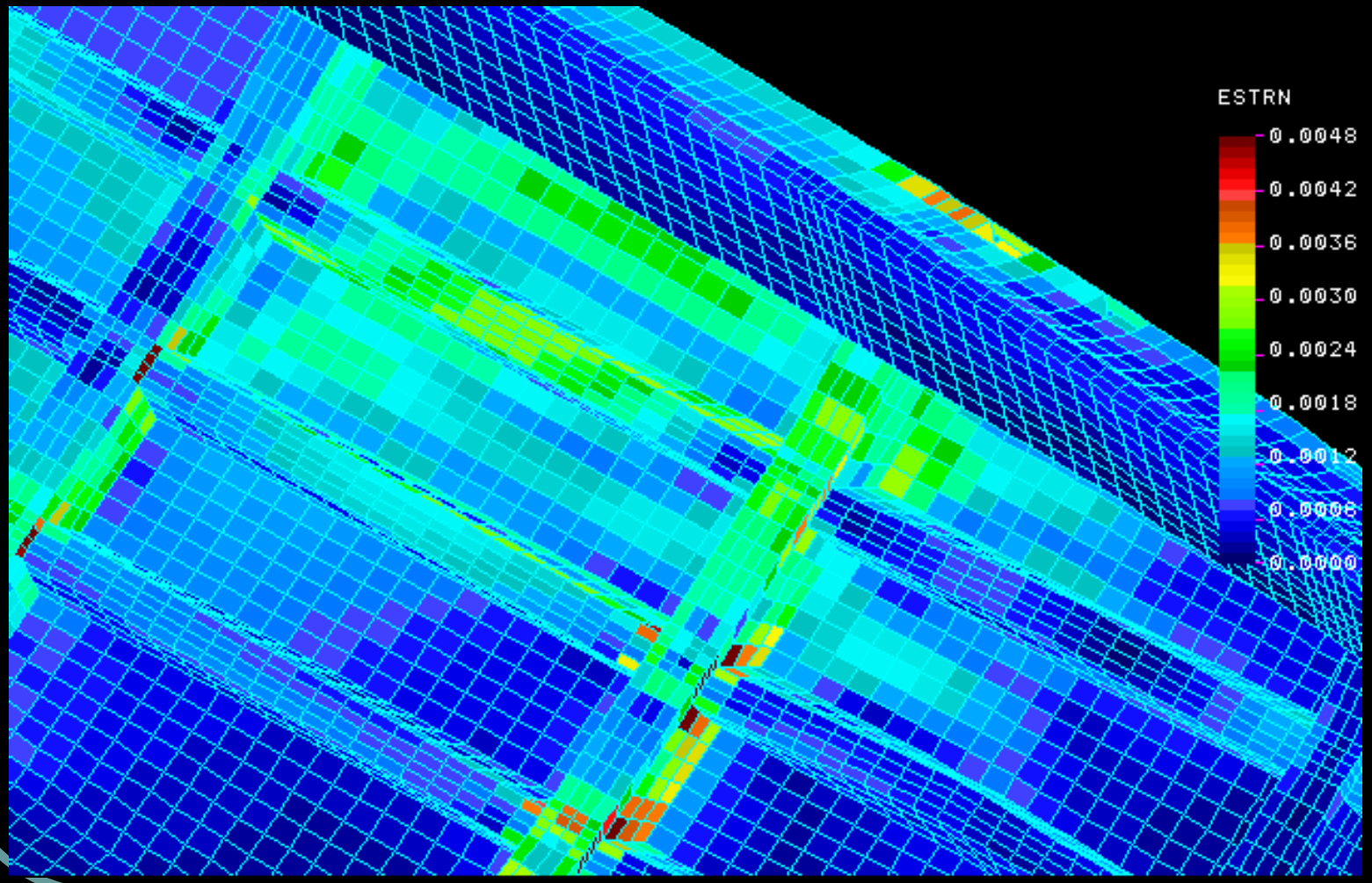
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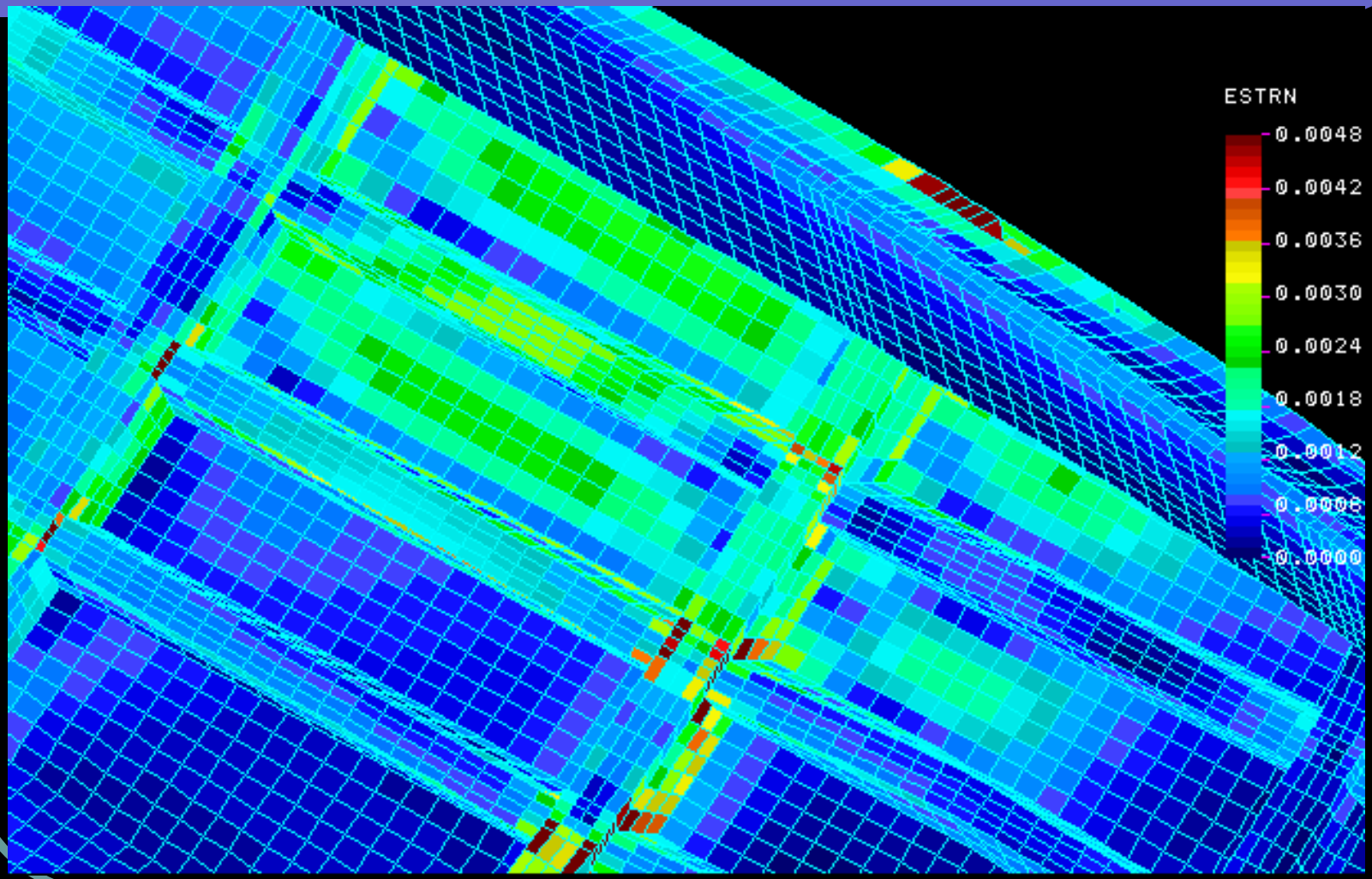
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LC6 - AL - FMO- Inside Surface Strain



LC6 - AL- FMO- Outside Surface Strain

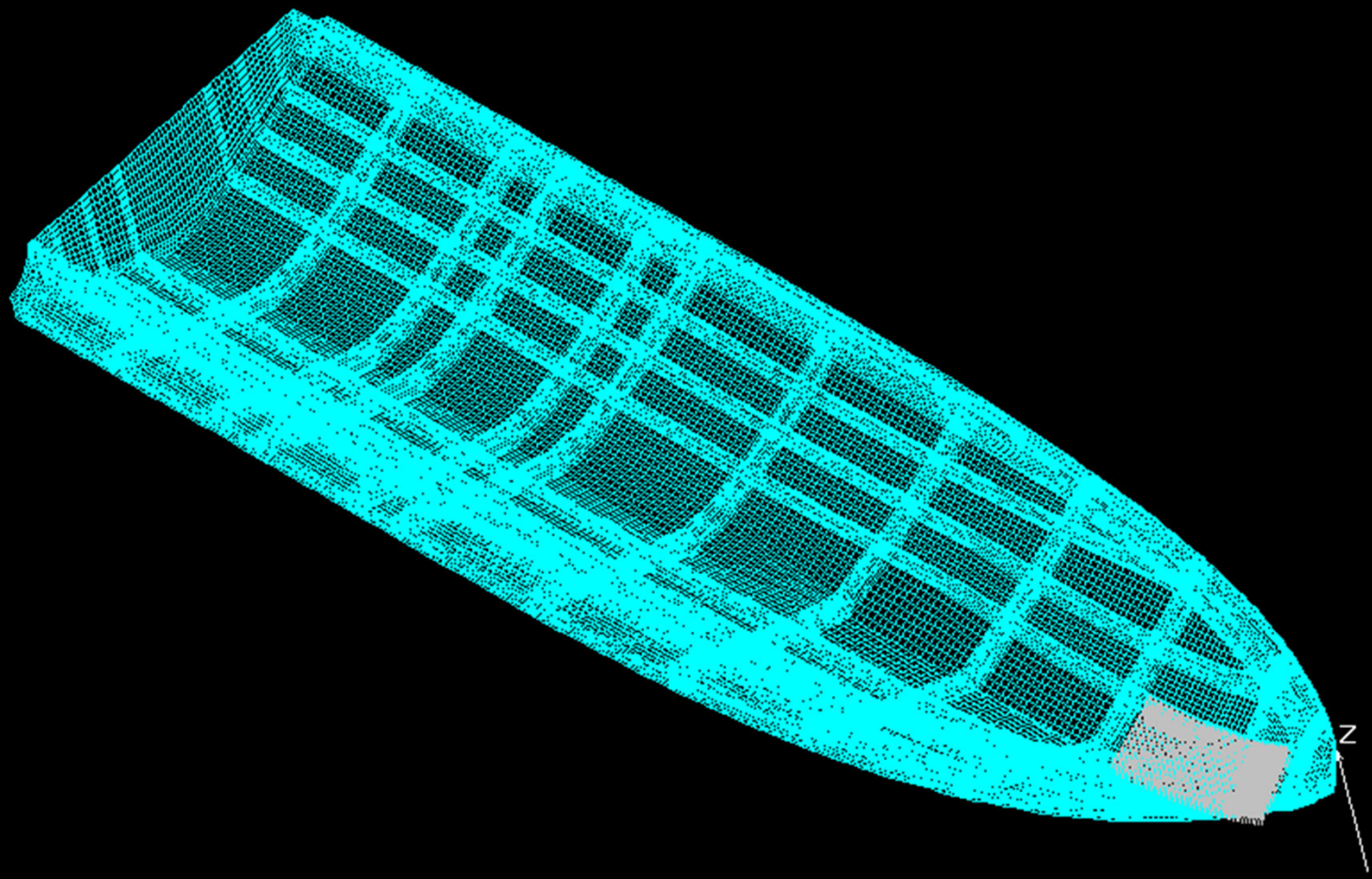


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LC6 – AL - FMO- Summary

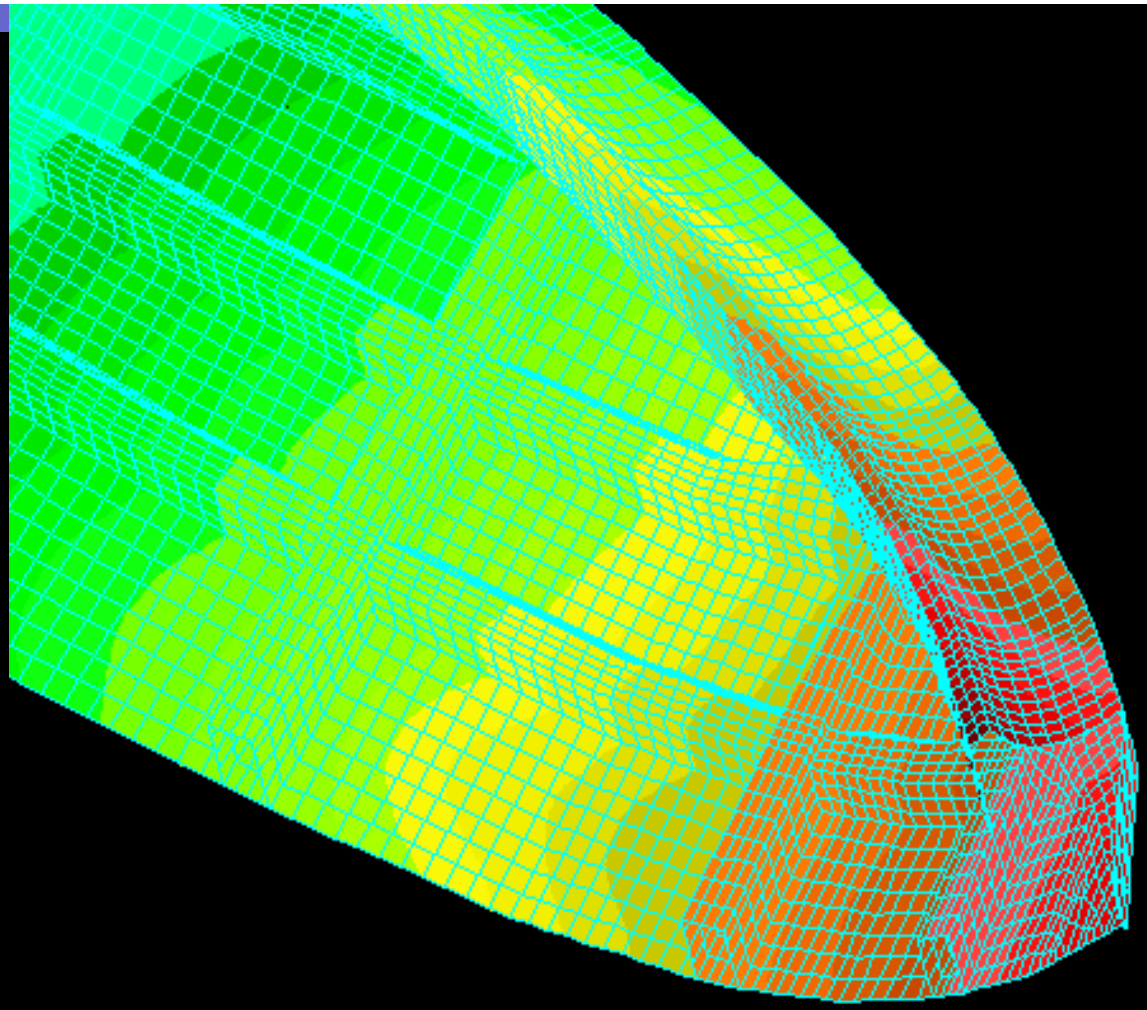
- Hull range of deflection 4.49 in.
- Maximum Hull strain 0.003 in/in
- Maximum Hull stress 24,000 psi
- Maximum framing strain 0.0036 in/in
- Maximum framing stress 19,000 psi

LC7- AL – FI -10 psi Pressure Load



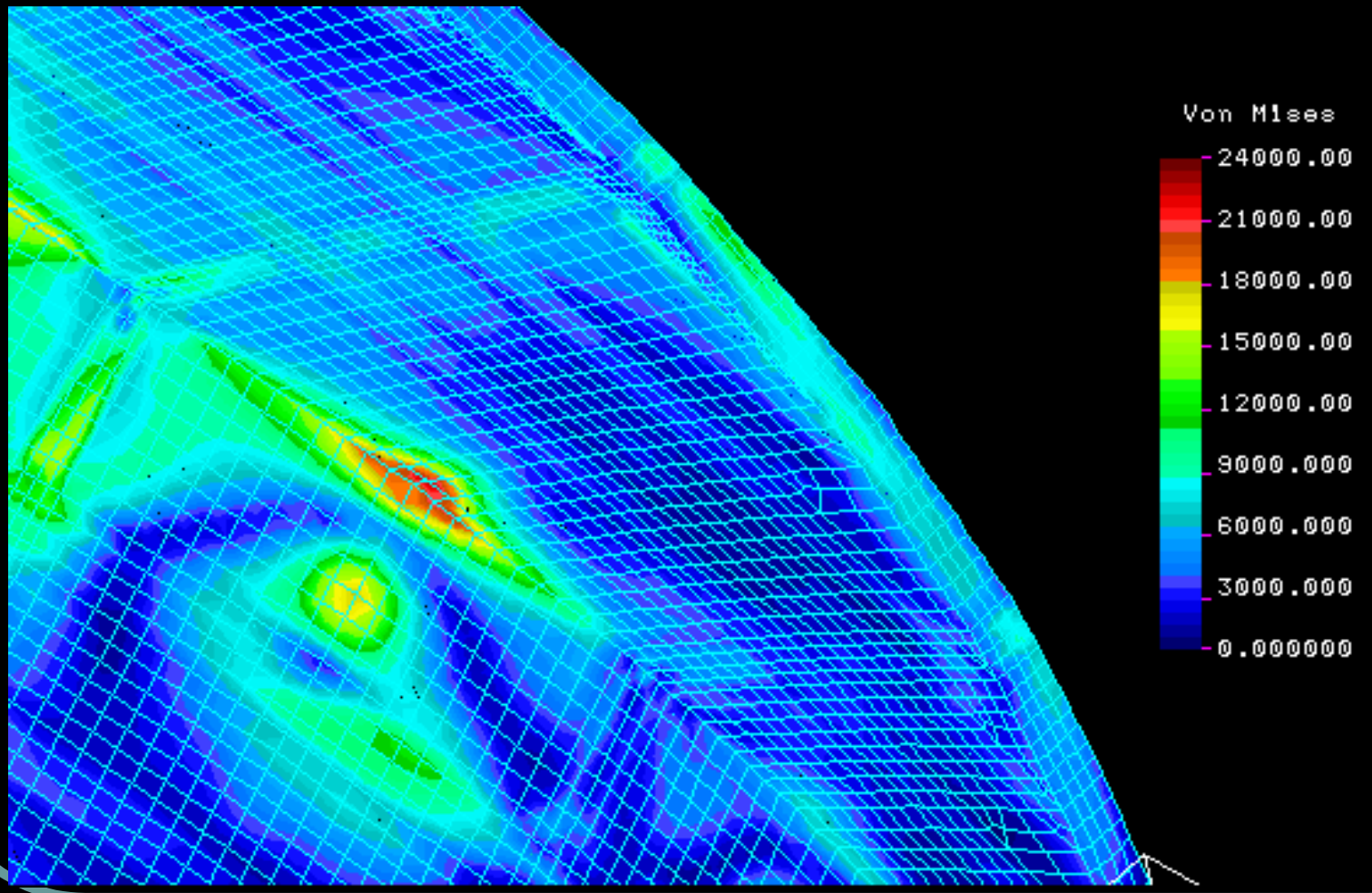
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LC7 - AL – FI - Z Hull Displacement

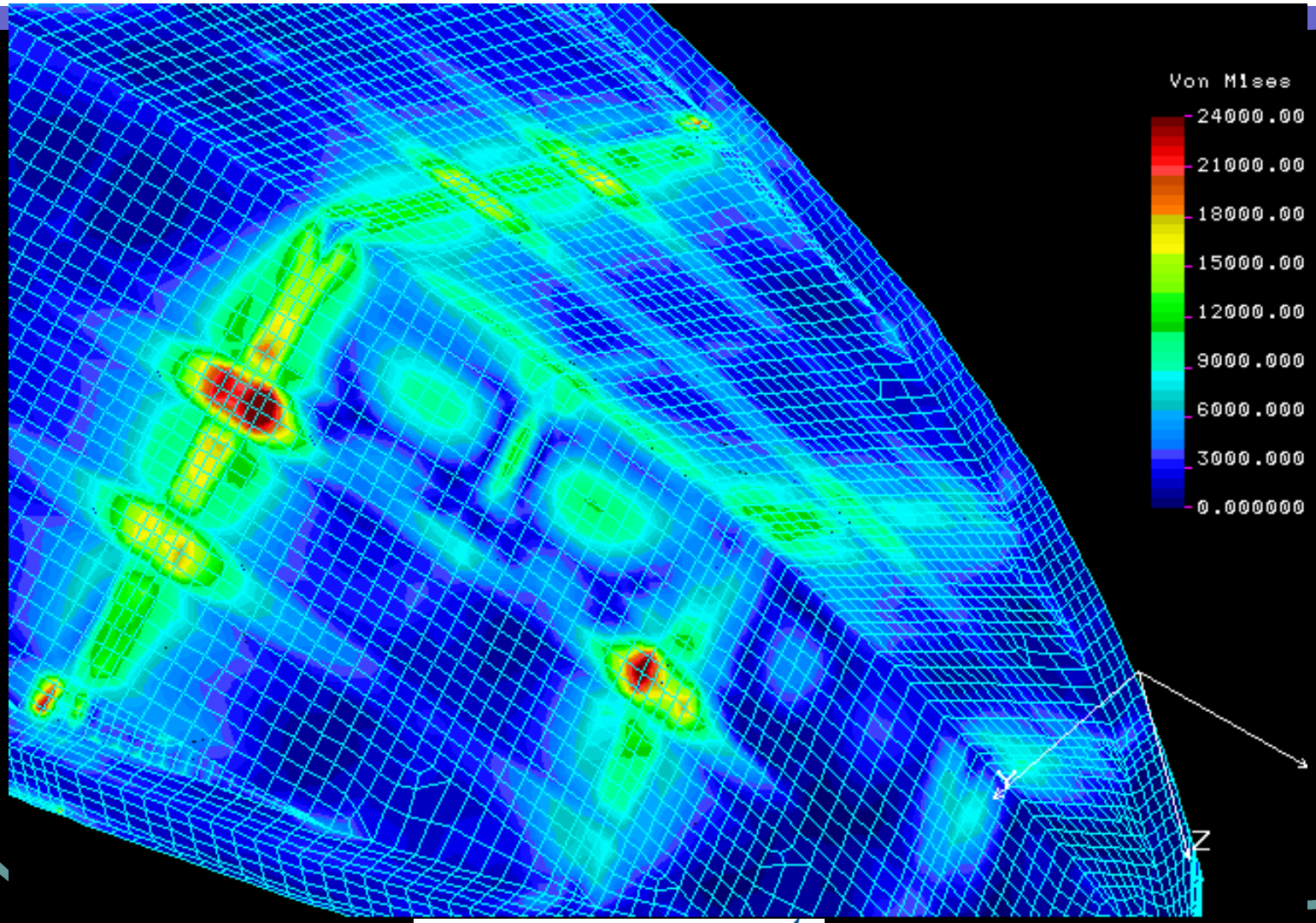


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LC7 – AL – FI - Transverse Carbon Ply Stress

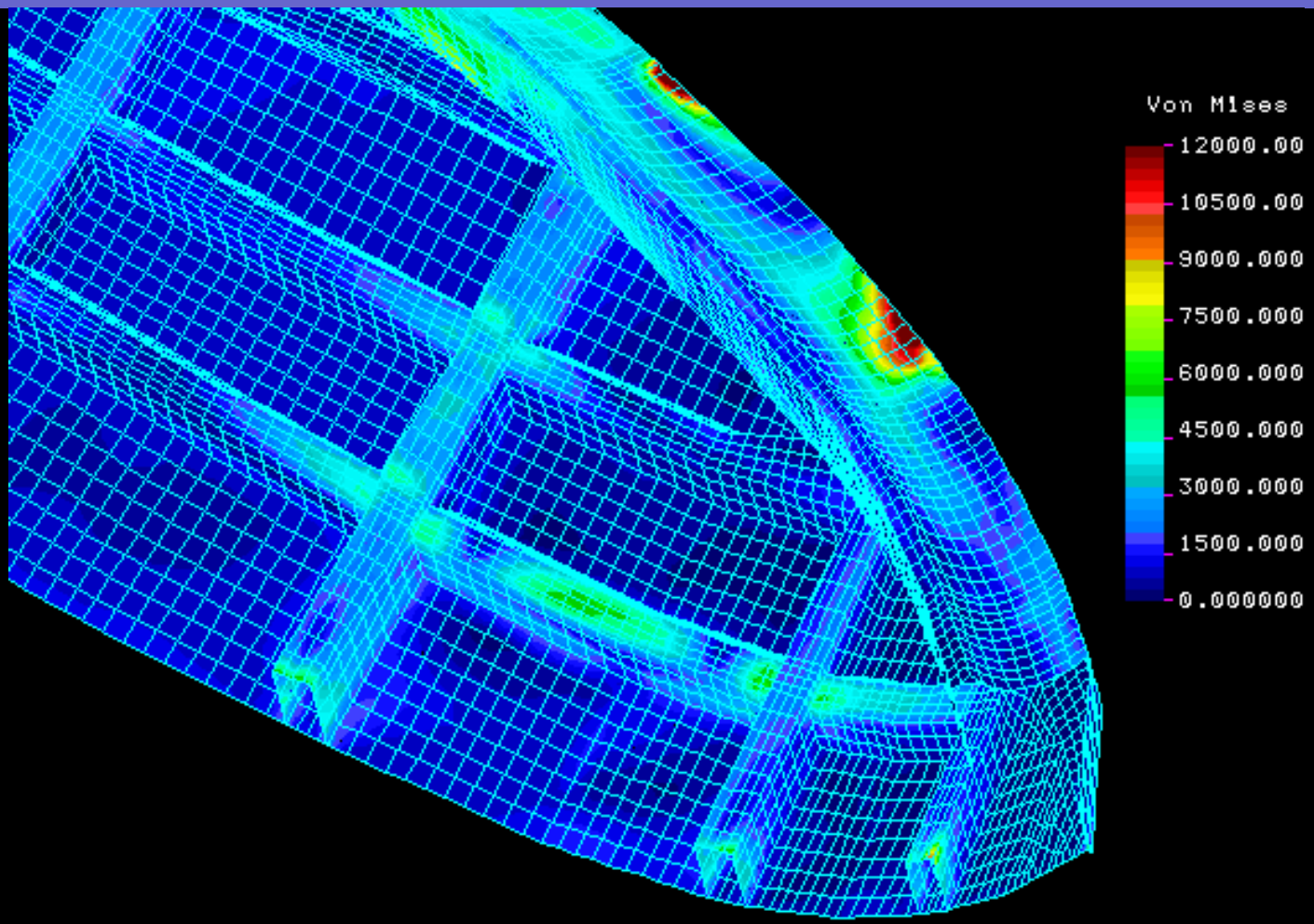


LC7-AL - FMI- Longitudinal Carbon Ply Stress

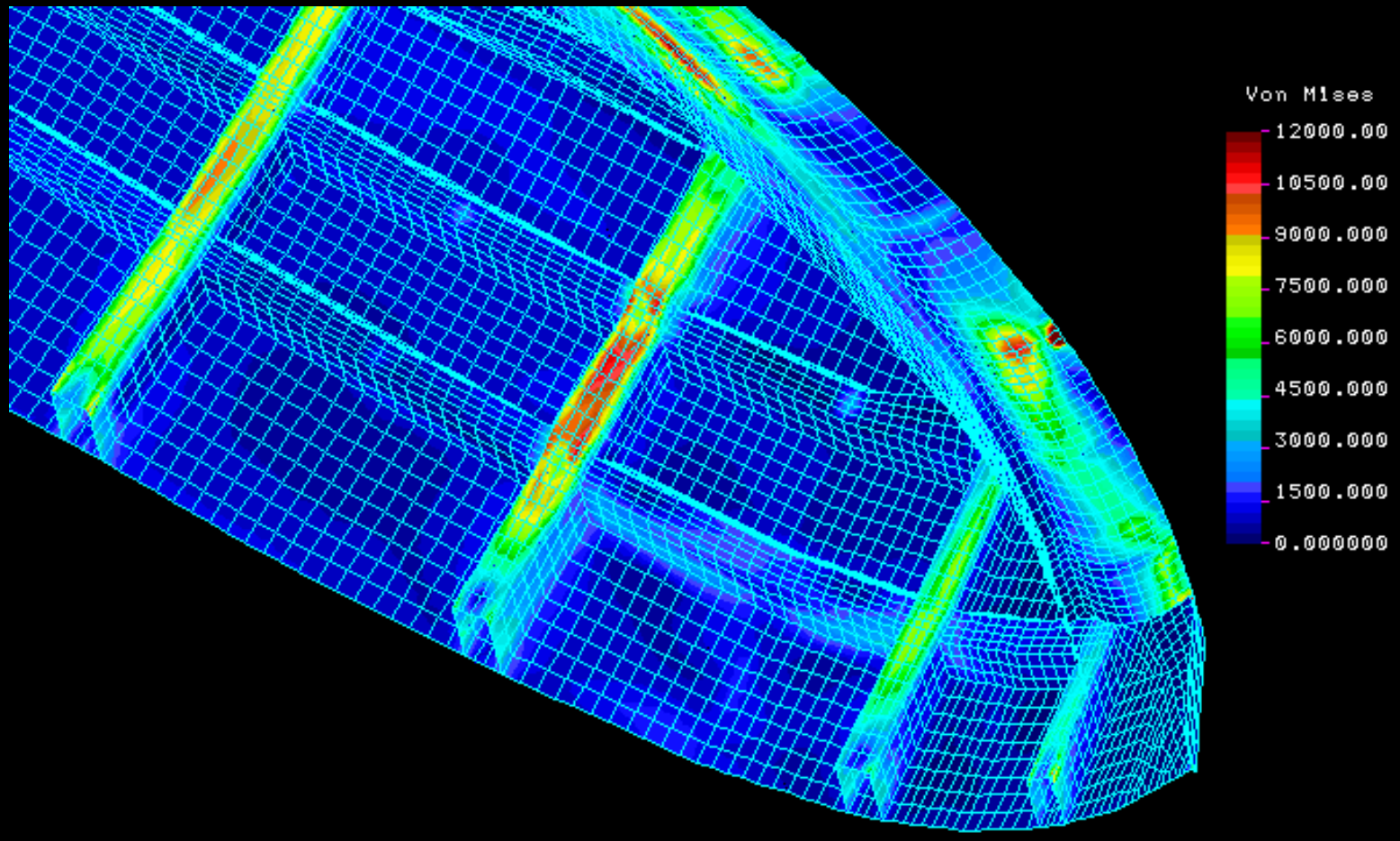


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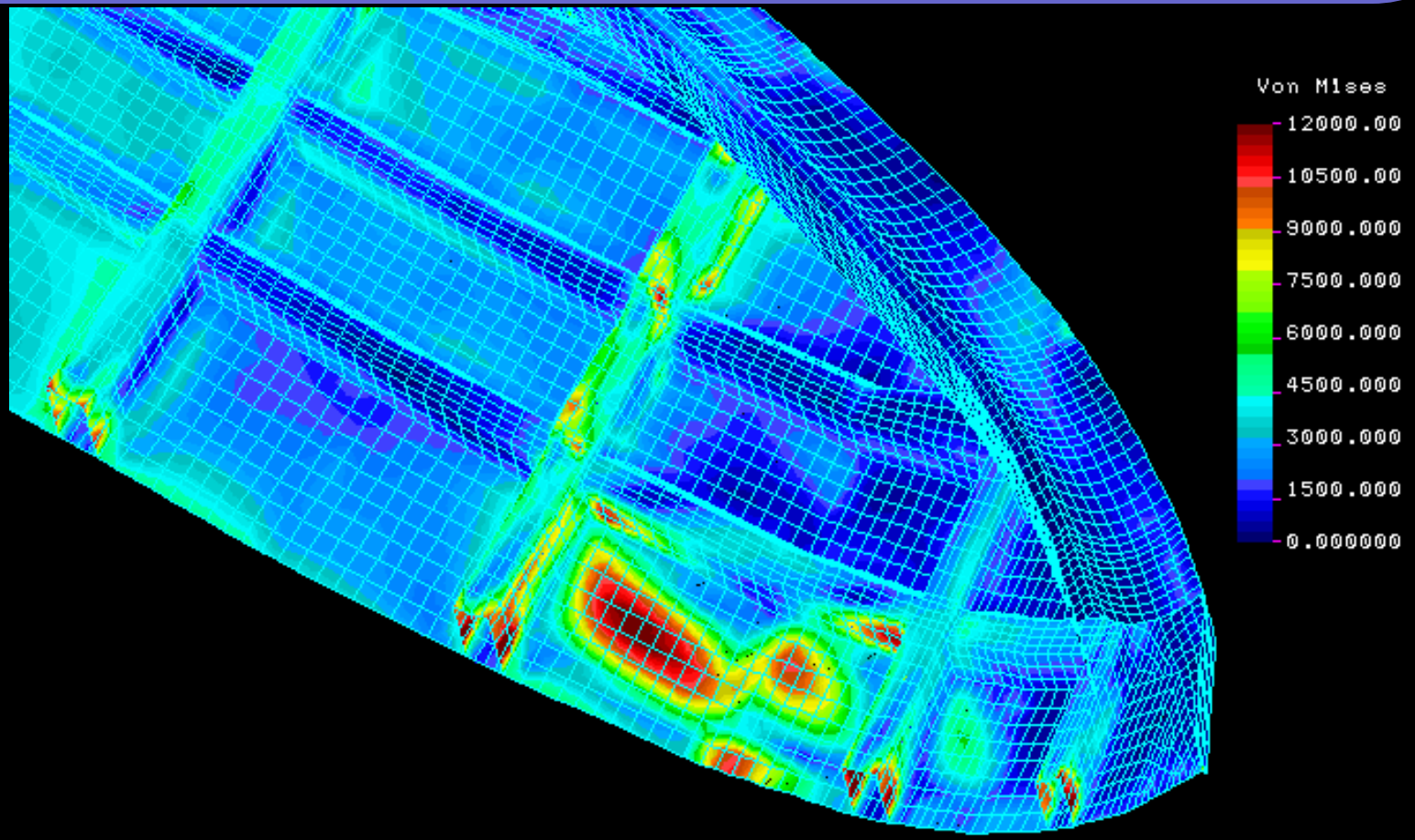
LC7 - AL - FI-Longitudinal Stringer Cap Stress



LC7 - AL - FI- Transverse Frame Cap Stress

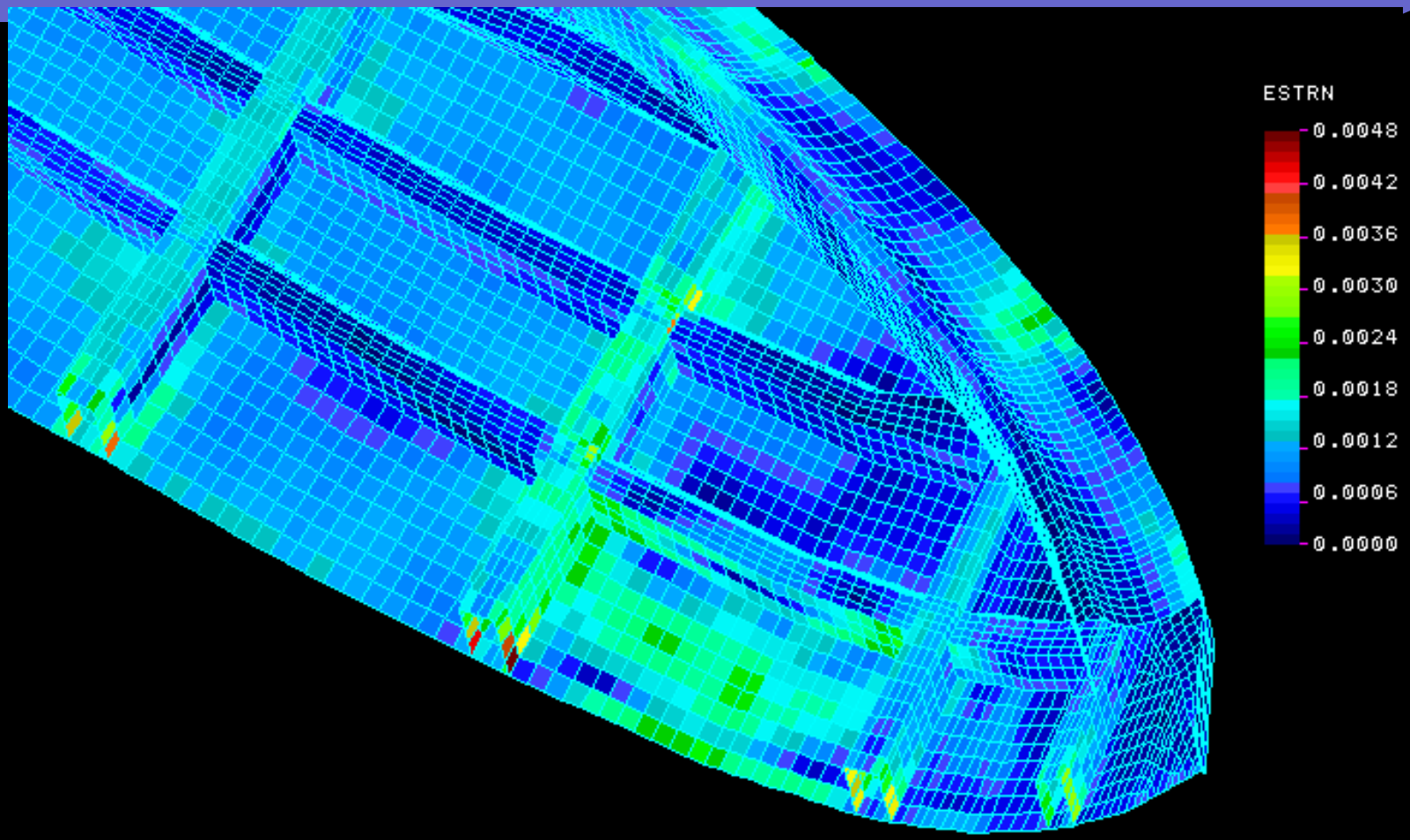


LC7-AL - FI- 45 Ply Tab and Side Wall Stress

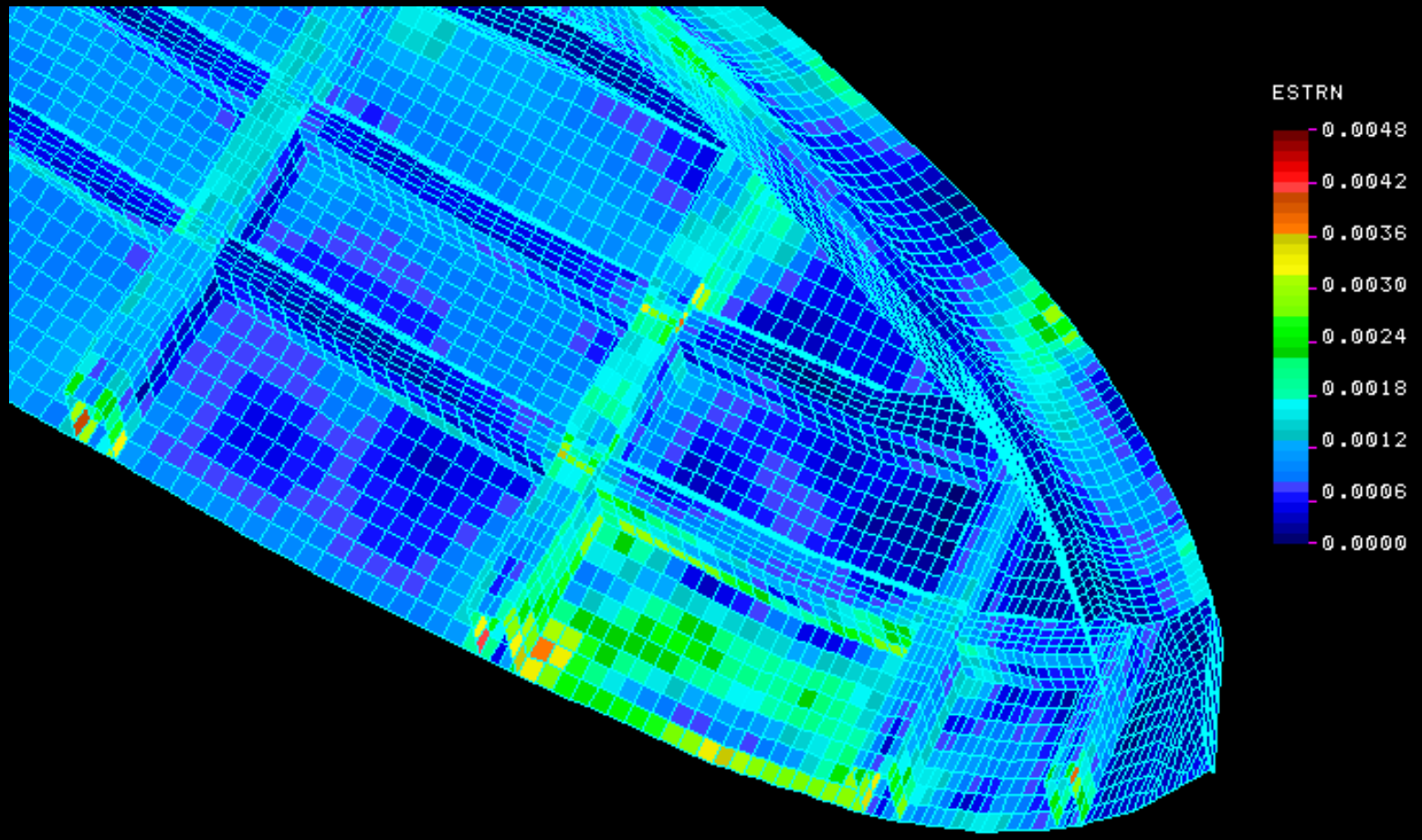


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LC7 – AL - FI- Inside Surface Strain



LC7-AL - FI- Outside Surface Strain



LC7-AL- FI- Summary

- Hull range of deflection to 12.02 in.
- Maximum Hull strain .0036 in/in
- Maximum Hull stress 24,000 psi
- Maximum framing .0033 strain
- Maximum framing stress 12,000 psi

LC(1-7)- SAS Summary

Range of maximum values in SAS cases

- Hull range of deflection 0.21 to 12.02 in.
- Maximum Hull strain 0.0048 in/in
- Maximum Hull stress 24,000 psi
- Maximum Frame strain 0.0048 in/in
- Max framing stress to 19,000 psi

136

11M- FEA Analysis: Boat Lifting Points (B.L.P.)



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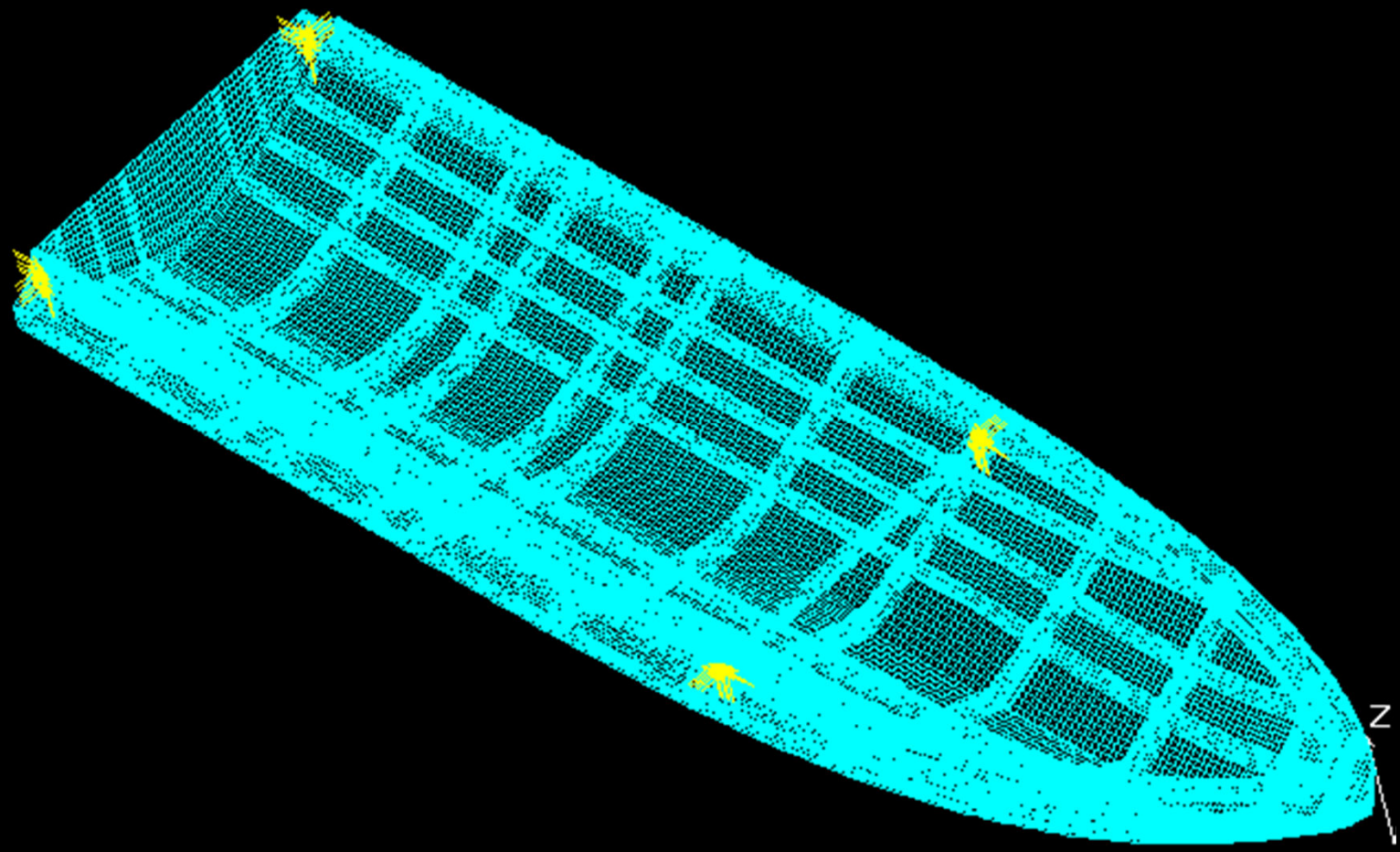
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
- 55,490 lbs at engine mounts (from constraints)
- -50,110 lbs distributed load (-1 lb at each of 50,110 nodes)
- Total weight 105,600 lbs (6 x 17,600 lbs

LC8- BLP- Load Data

- Vertical loads
  - 26,400 lbs at each point
  - 105,600 lbs total (6 x 17,600 lbs)
- Transverse loads
  - -1056 lbs stbd side lift points
  - 1056 lbs port side lift points
- Longitudinal loads
  - 13,200 lbs at aft points
  - -13,200 lbs at fwd points

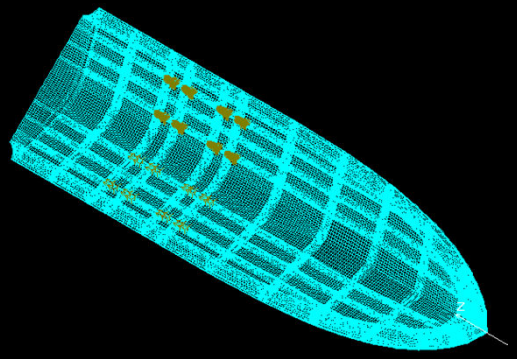
LC8- BLP- Force Vector at Lift Points



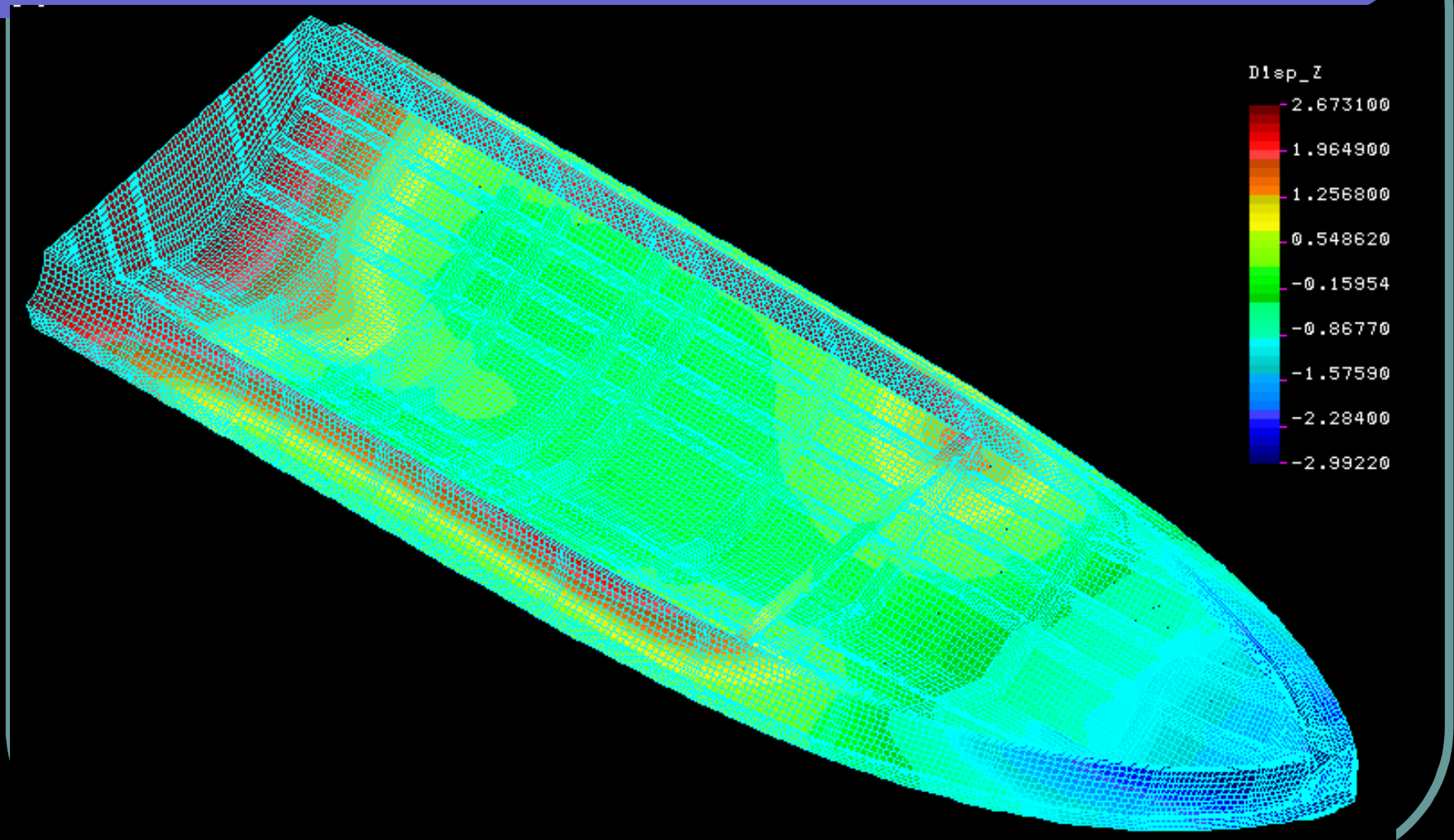
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LC8- BLP- Constraints

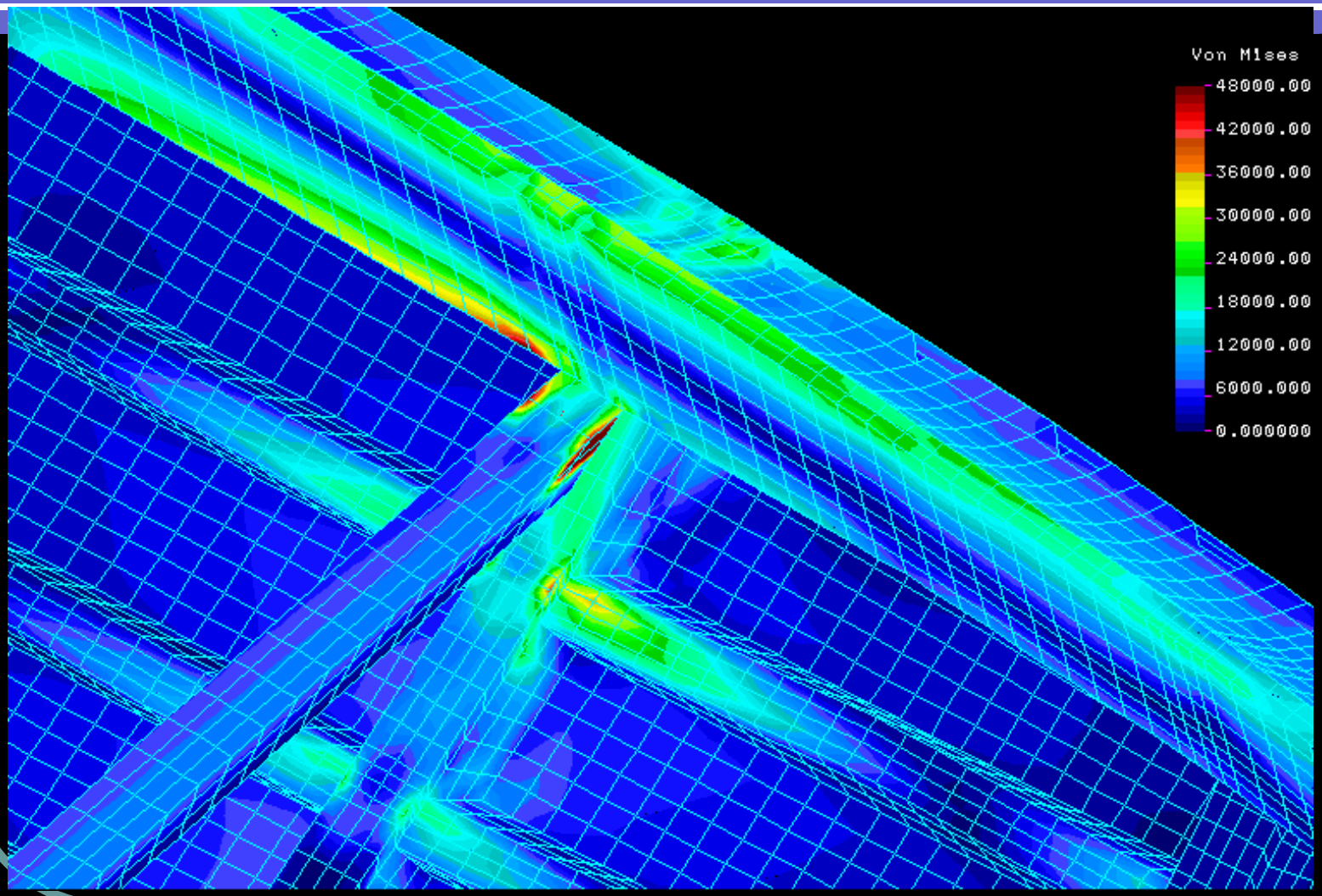
- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints F_r < 1 lb
- Thus constraints do not affect results



LC8- BLP- Vertical Displacement



LC8- BLP- Longitudinal Ply- Fwd Lift Point



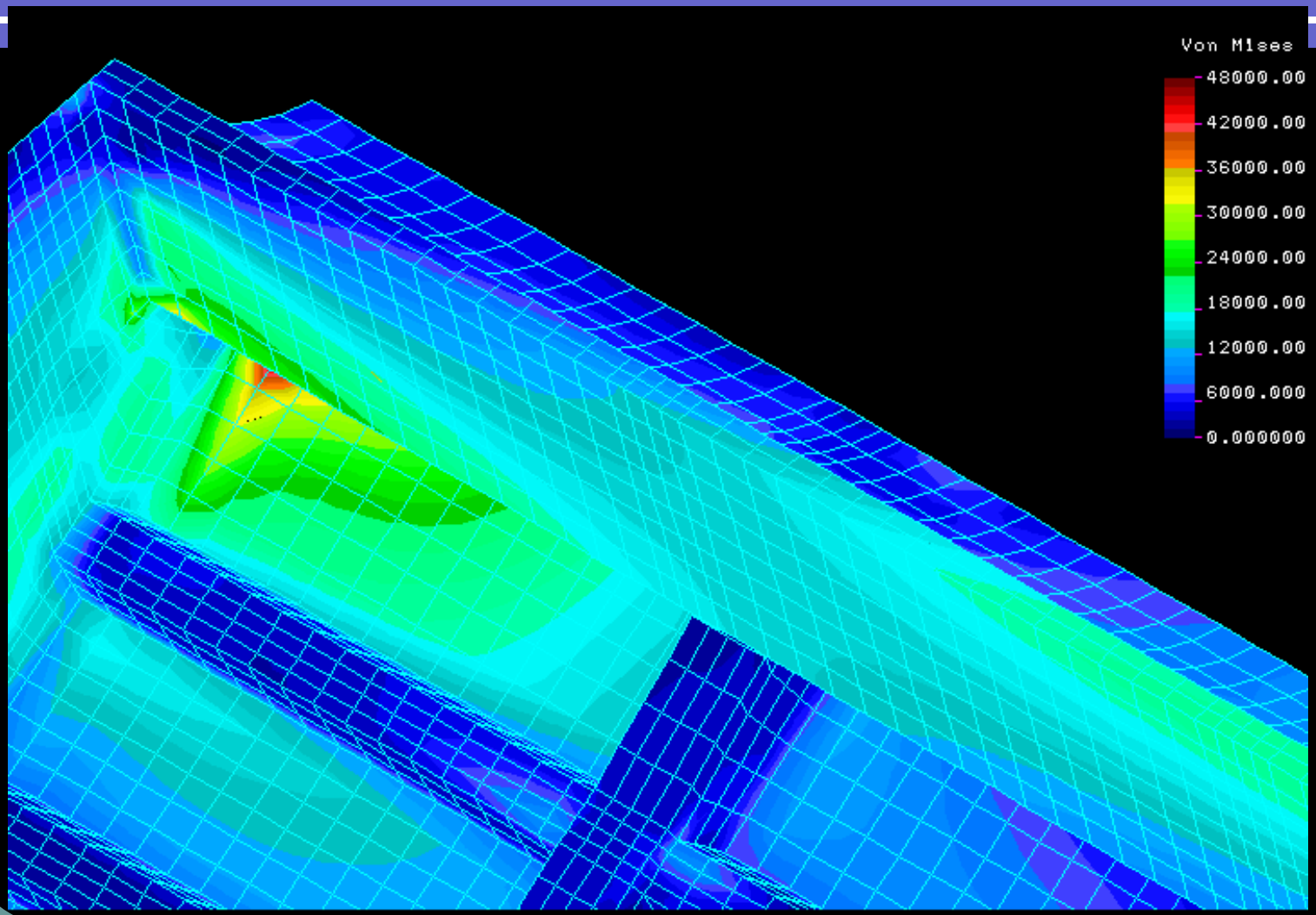
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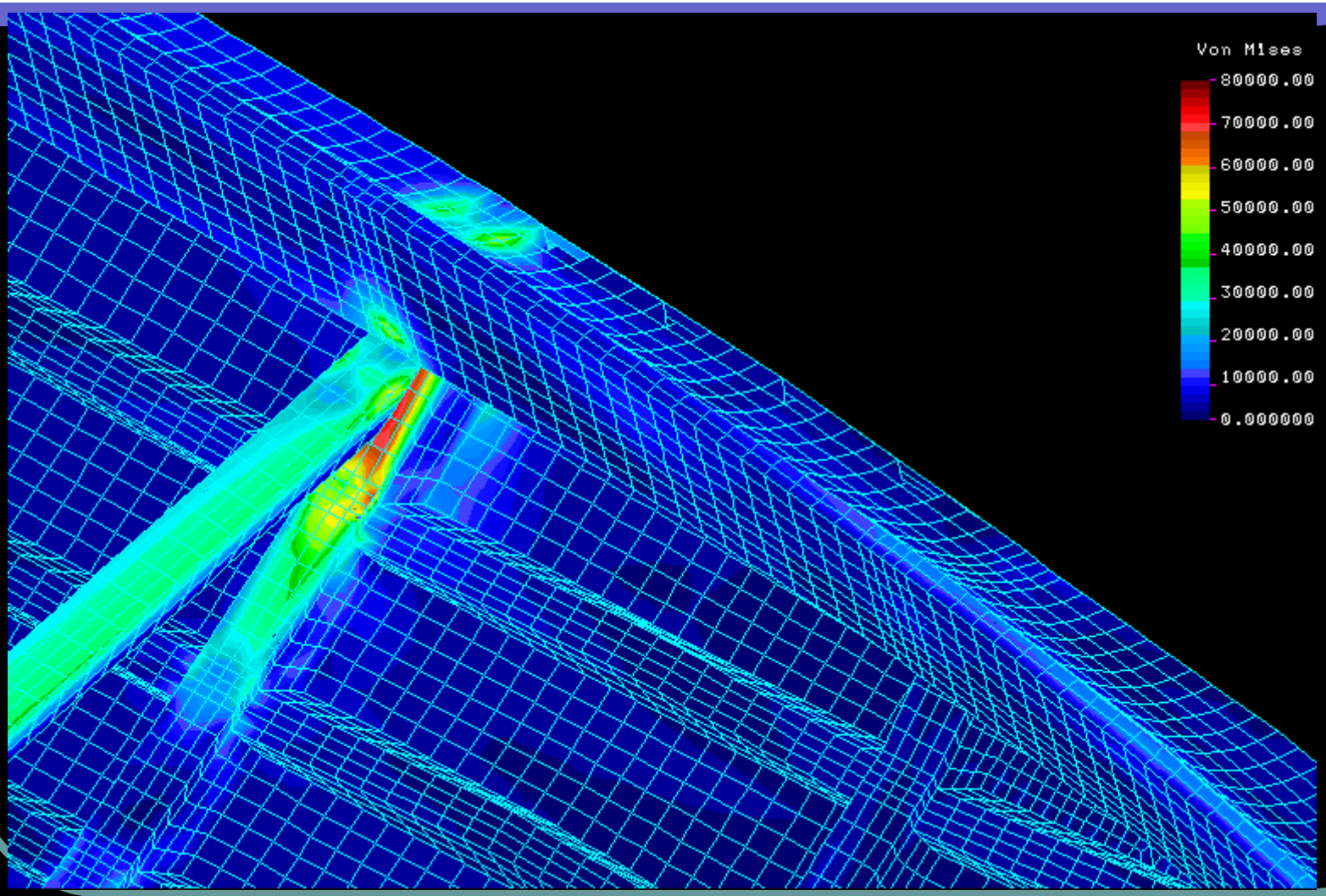
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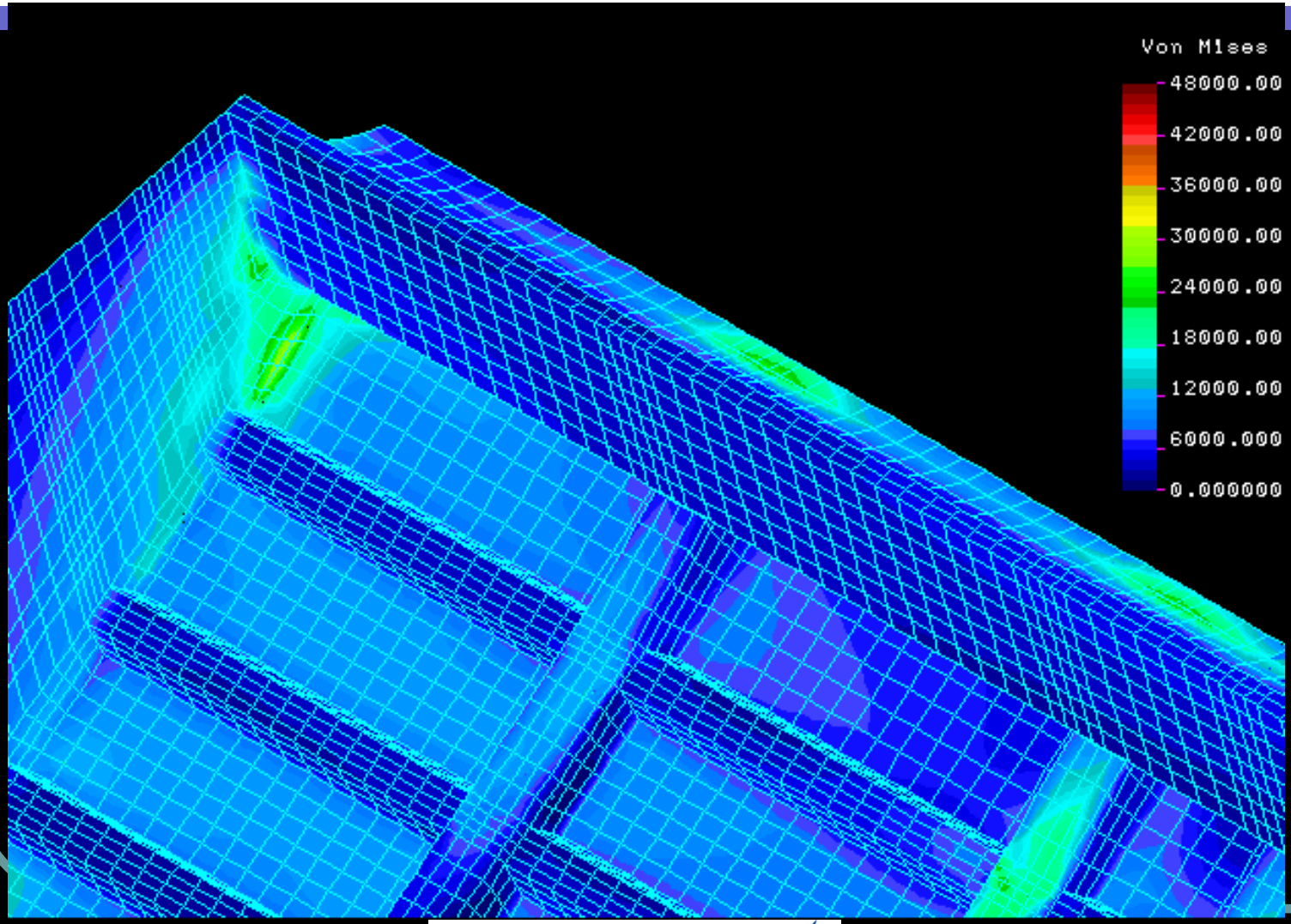
LC8- BLP- Longitudinal Ply- Aft Lift Point



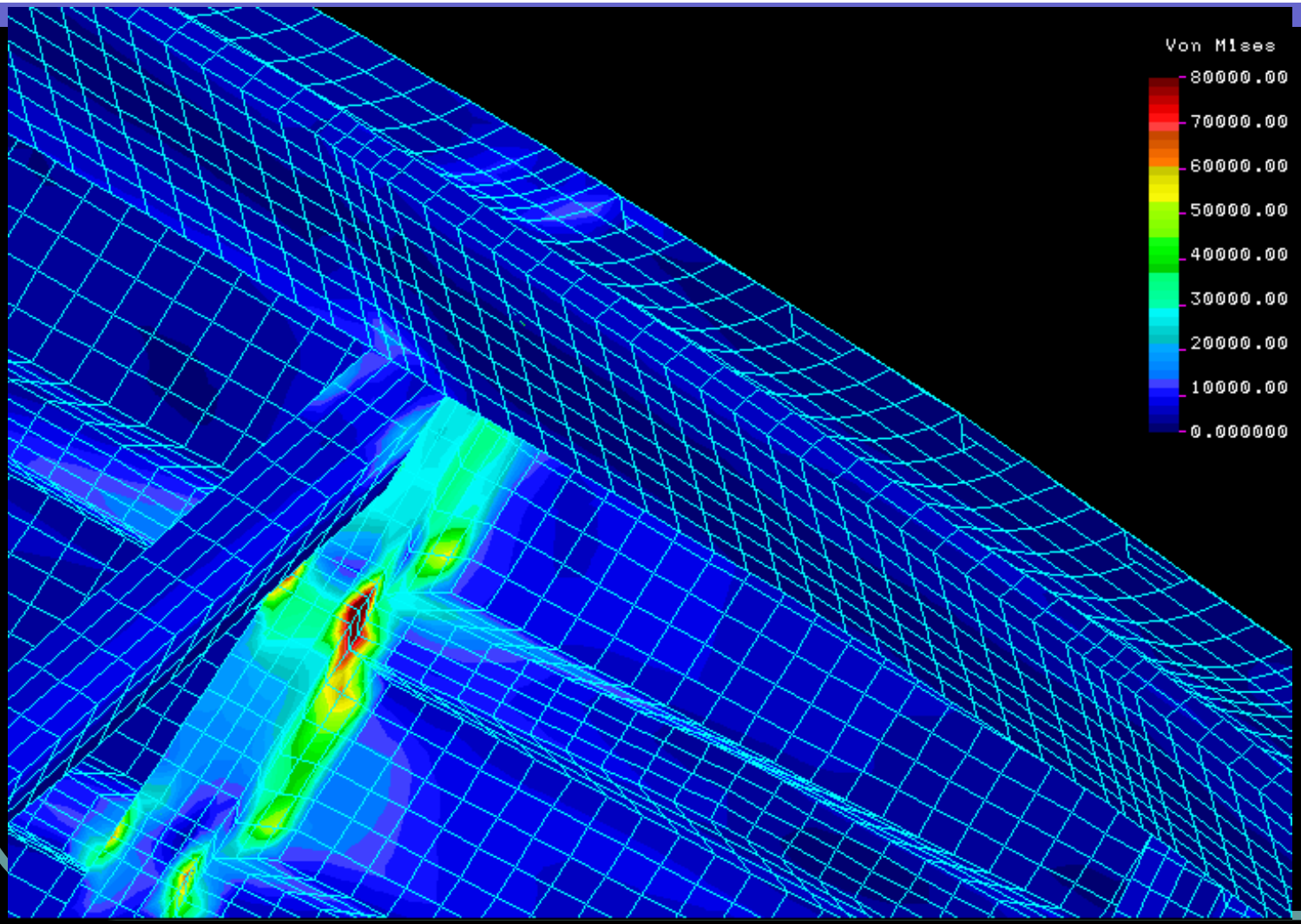
LC8- BLP-Transverse Ply- Fwd Lift Point



LC8- BLP- Transverse Ply- Aft Lift Point



LC8- BLP- 45Ply- Fwd Lift Point



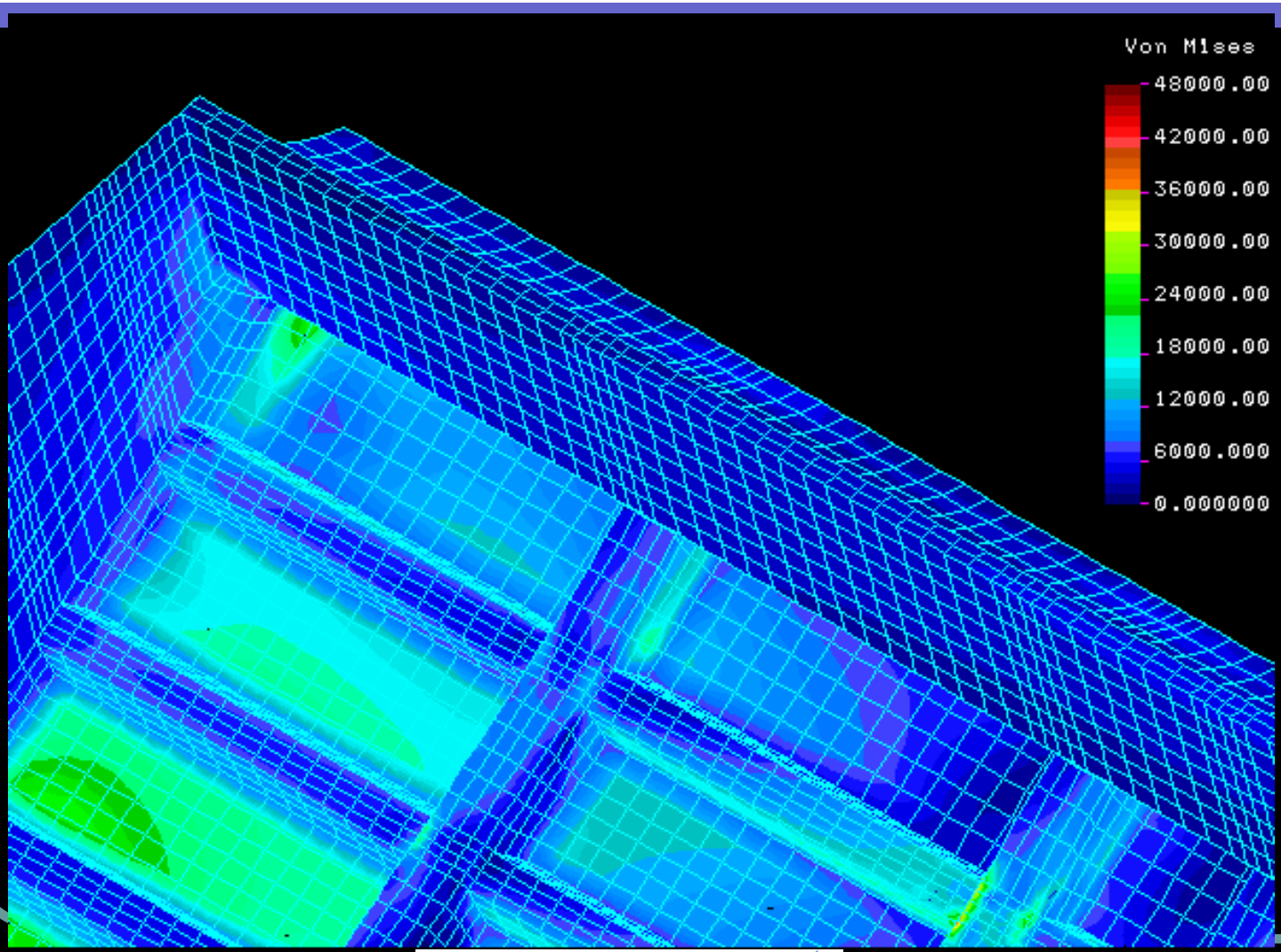
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LC8 - BLP- 45 Ply- Aft Lift Point



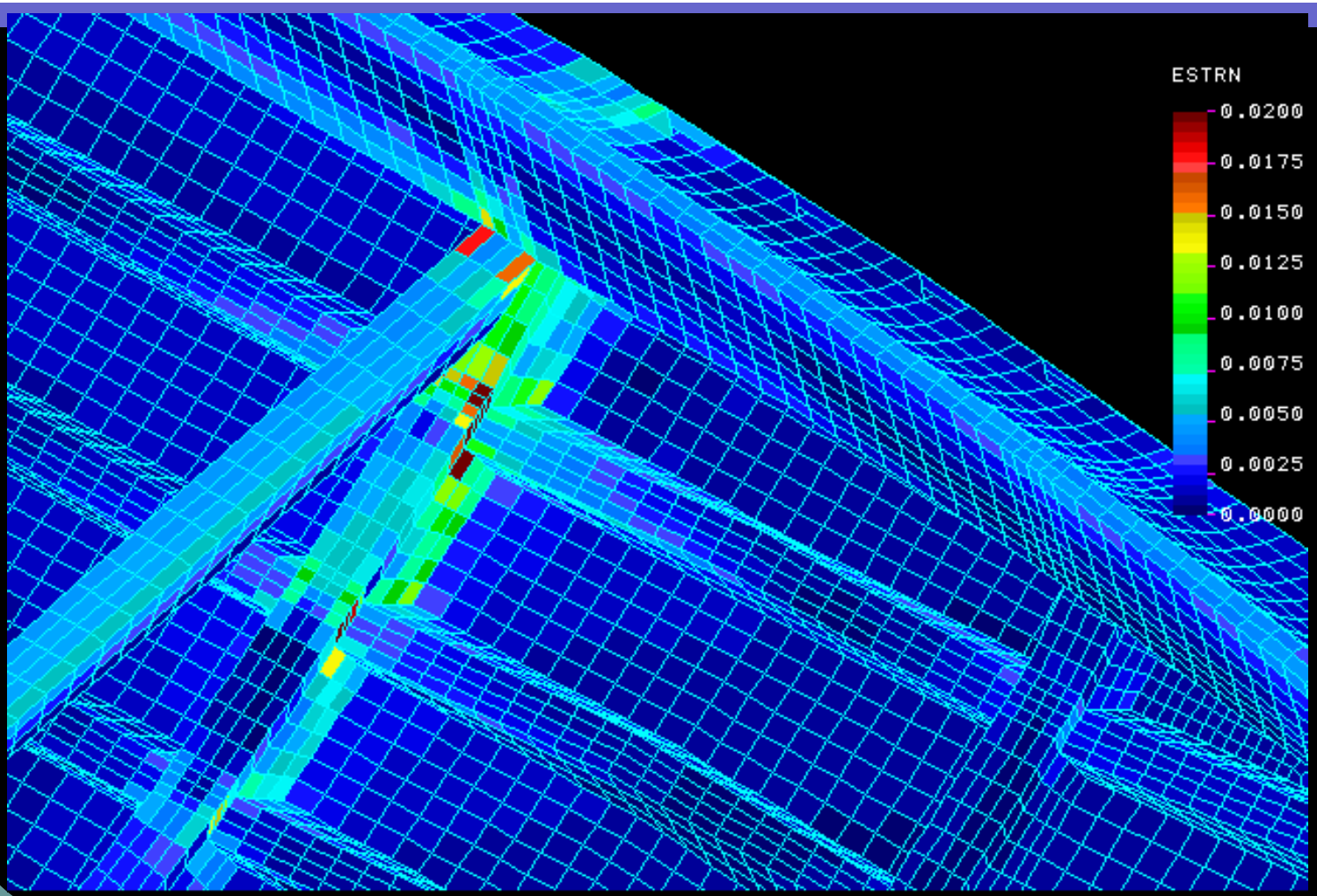
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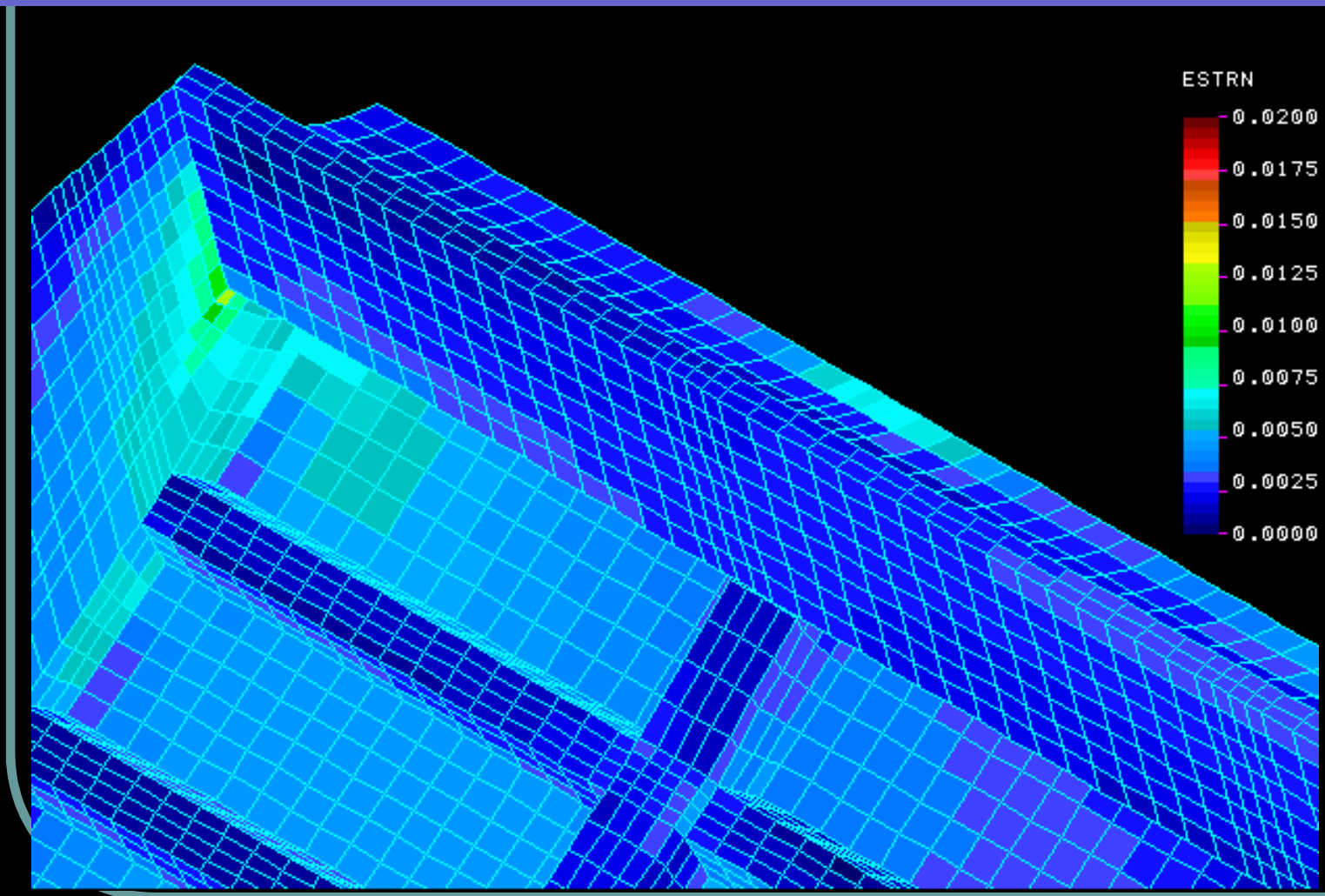
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LC8 - BLP- Strain- Fwd Lift Point



LC8 - BLP- Strain- Aft Lift Point



LC8 - BLP- Lift Analysis Summary

- Hull range of deflection -3.0 to 2.7 in.
- Maximum strain .02 in/in
- Maximum long stress 48,000 psi
- Maximum Transverse stress 70,000 psi
- Maximum 45 axis stress 80,000

151

11M- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)



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Gun Mount Framing Notes

- This is a stiffness design, thus stresses are low
- Four transverse frames, TR2030X, are placed on 3.5 in centers
- Skin laminate is 4 layers of E LTM 3610 (entire foredeck, including tube support areas)
- Frame laminate
  - 24 oz (+/-45) on PRISMA beam
  - 4 layers 4” wide E LM 1810 warp uni on frame caps
  - E BXM 2408 (+/-45) cover fabric (overlapping adjacent tabs)

LC9- GML- Long. Loading

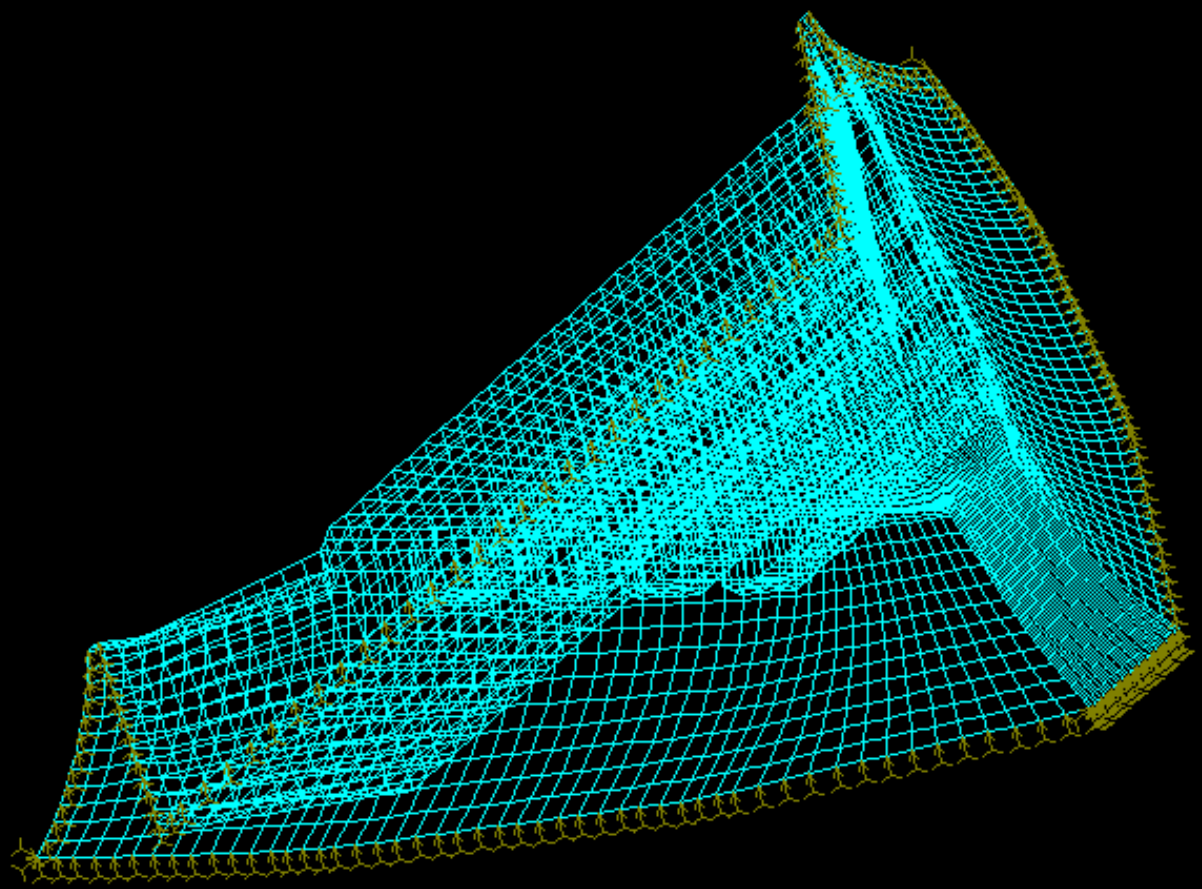
Forward

- Two bolts
- Tensile loading 2250 lbs each bolt

Aft

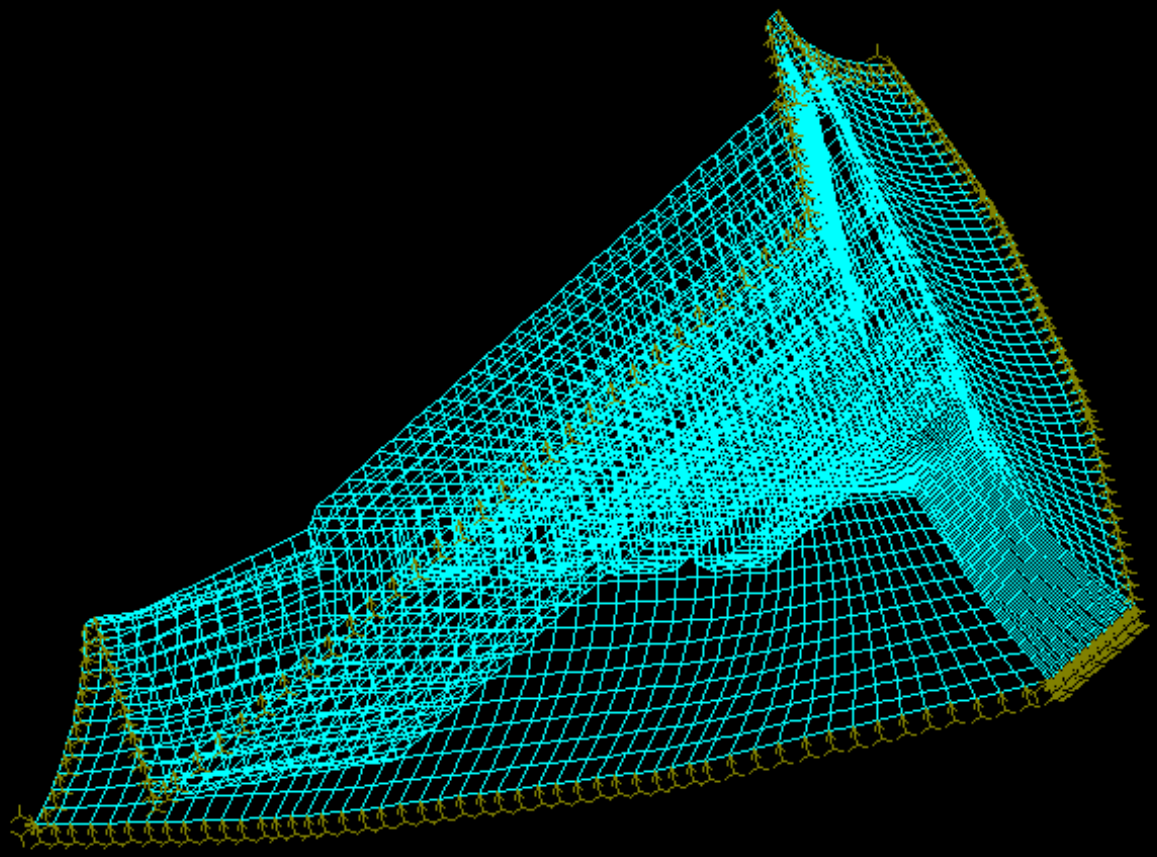
- Loading at 13 nodes along aft edge of mounting plate
- Compressive loading 347 lbs each point

LC9- GML- Long. Elements



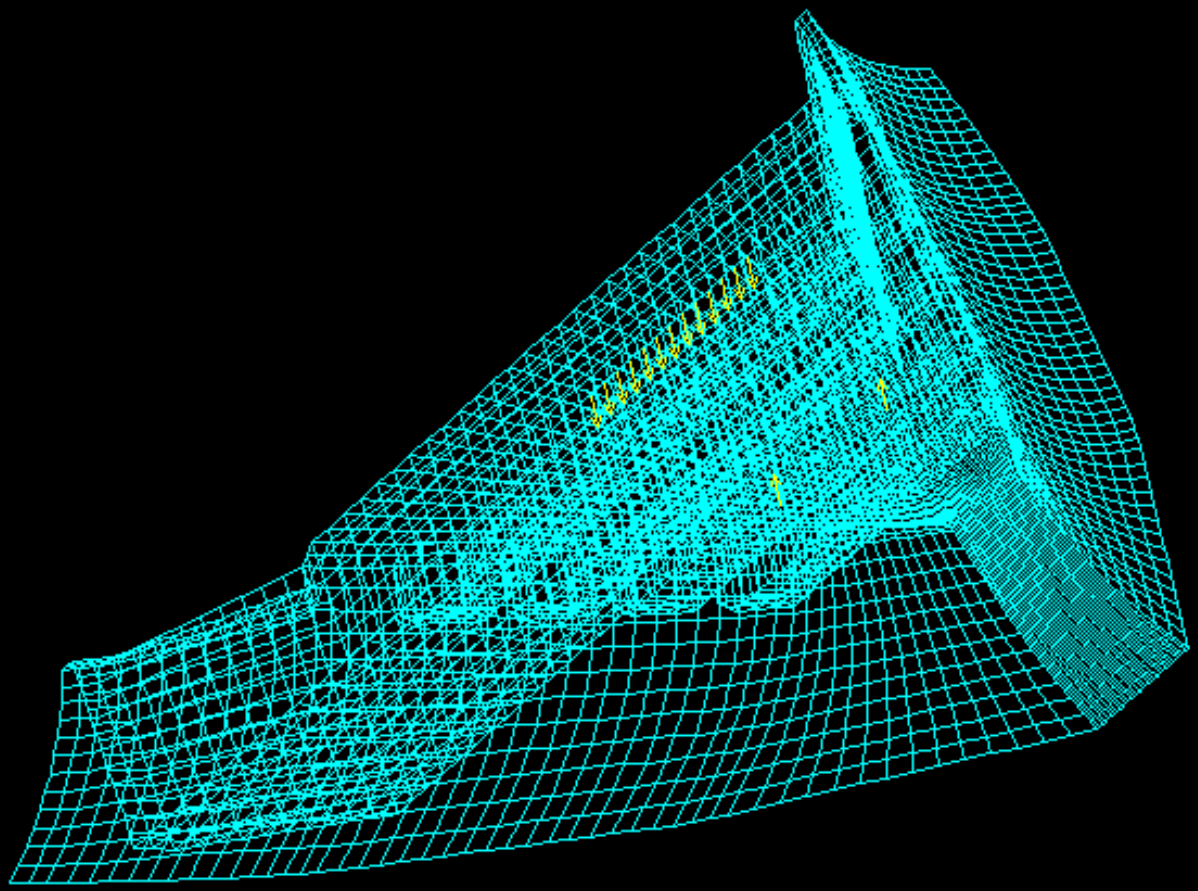
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LC9- GML- Long. Constraints



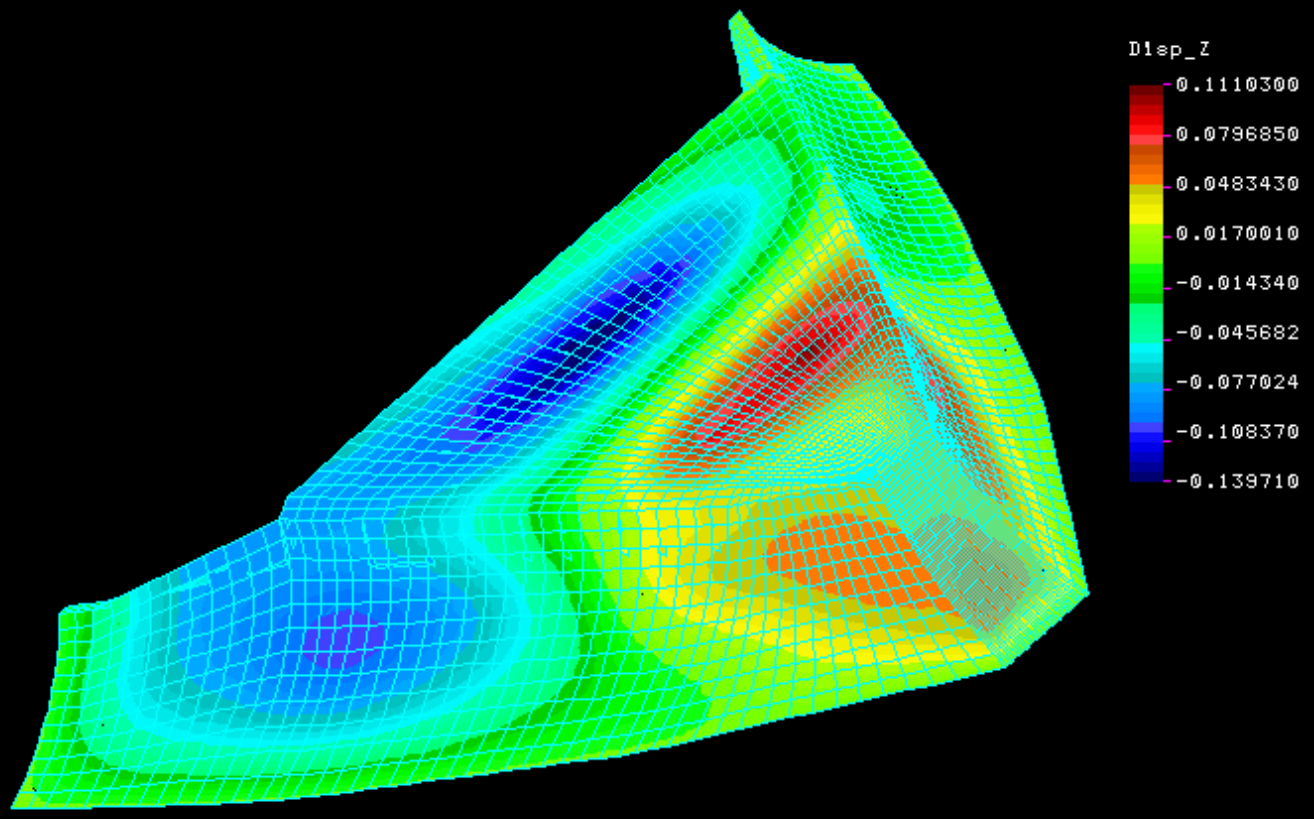
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LC9- GML- Long. Loading

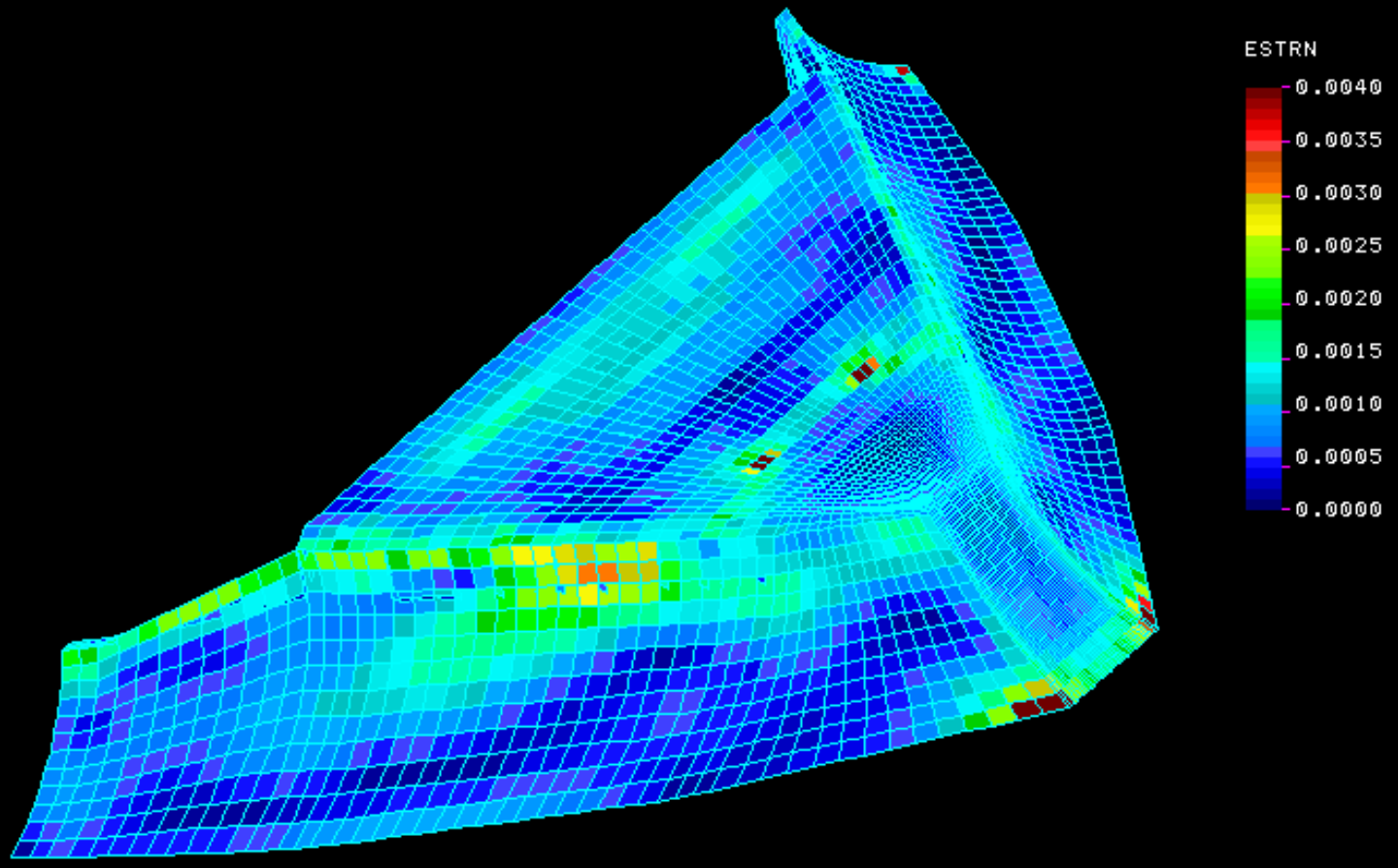


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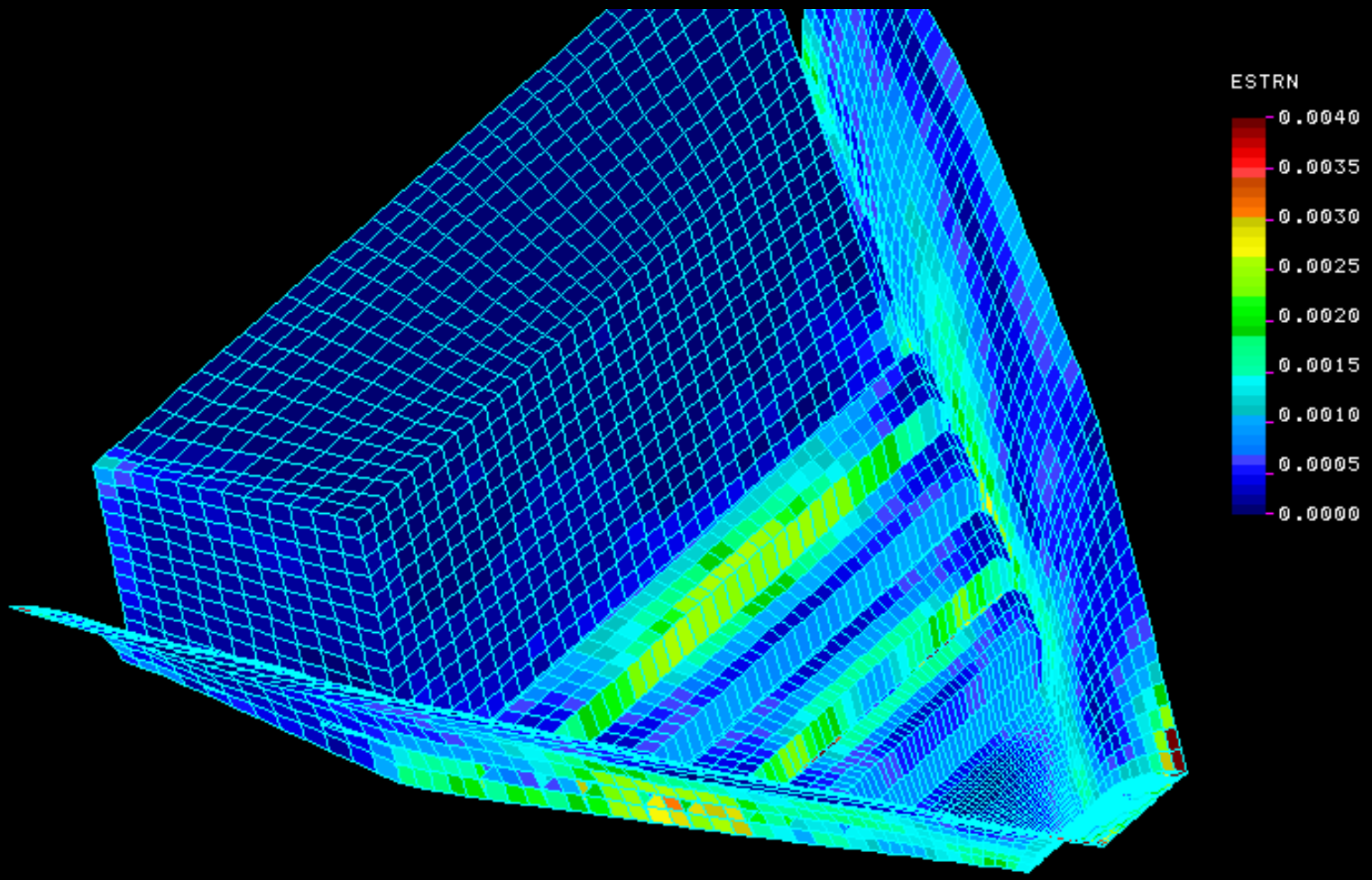
LC9- GML- Long. Loading Vertical Displacement



LC9- GML- Long. Loading 1st Layer Strain (Outside View)

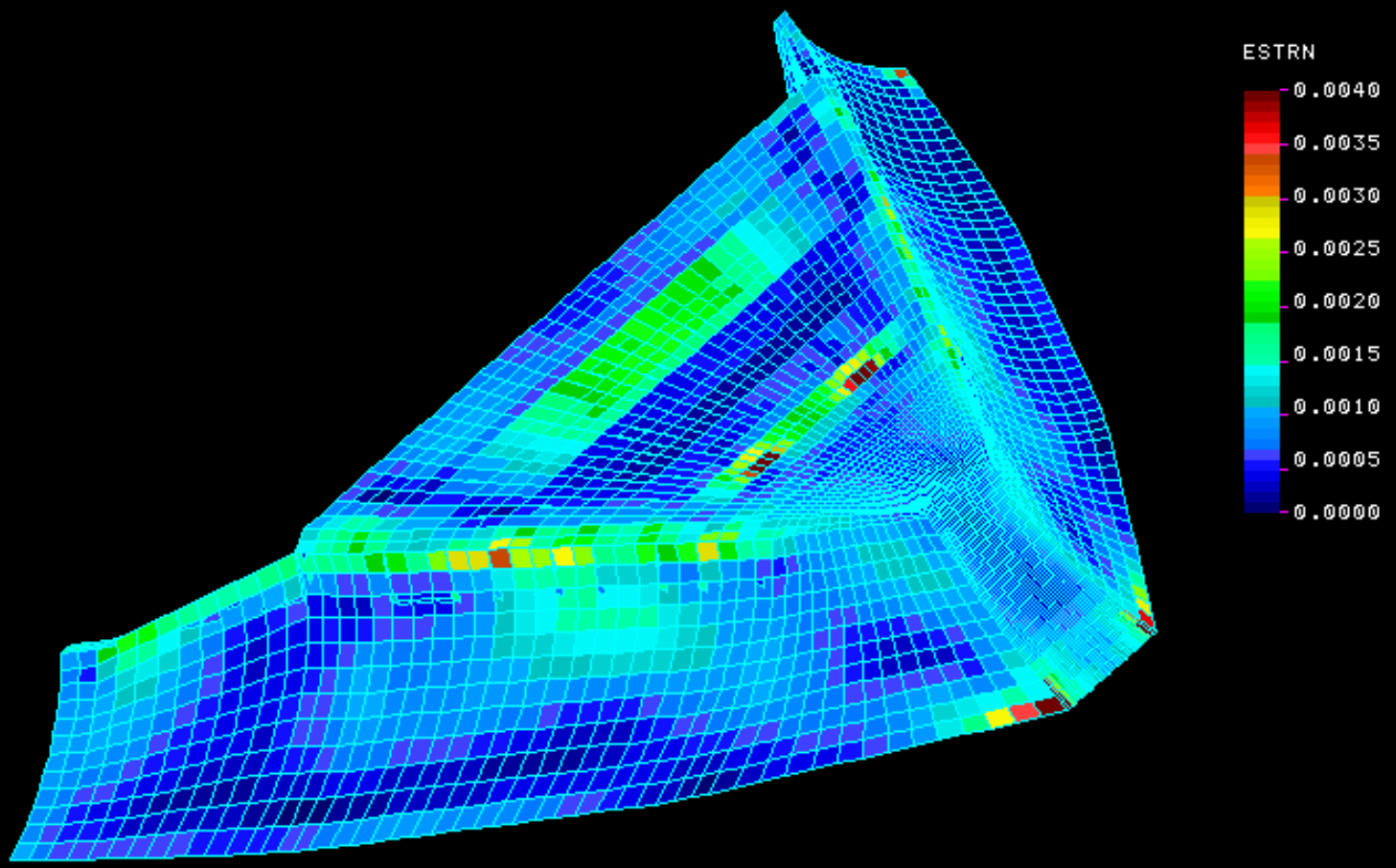


LC9- GML- Long. Loading 1st Layer Strain (Inside View)



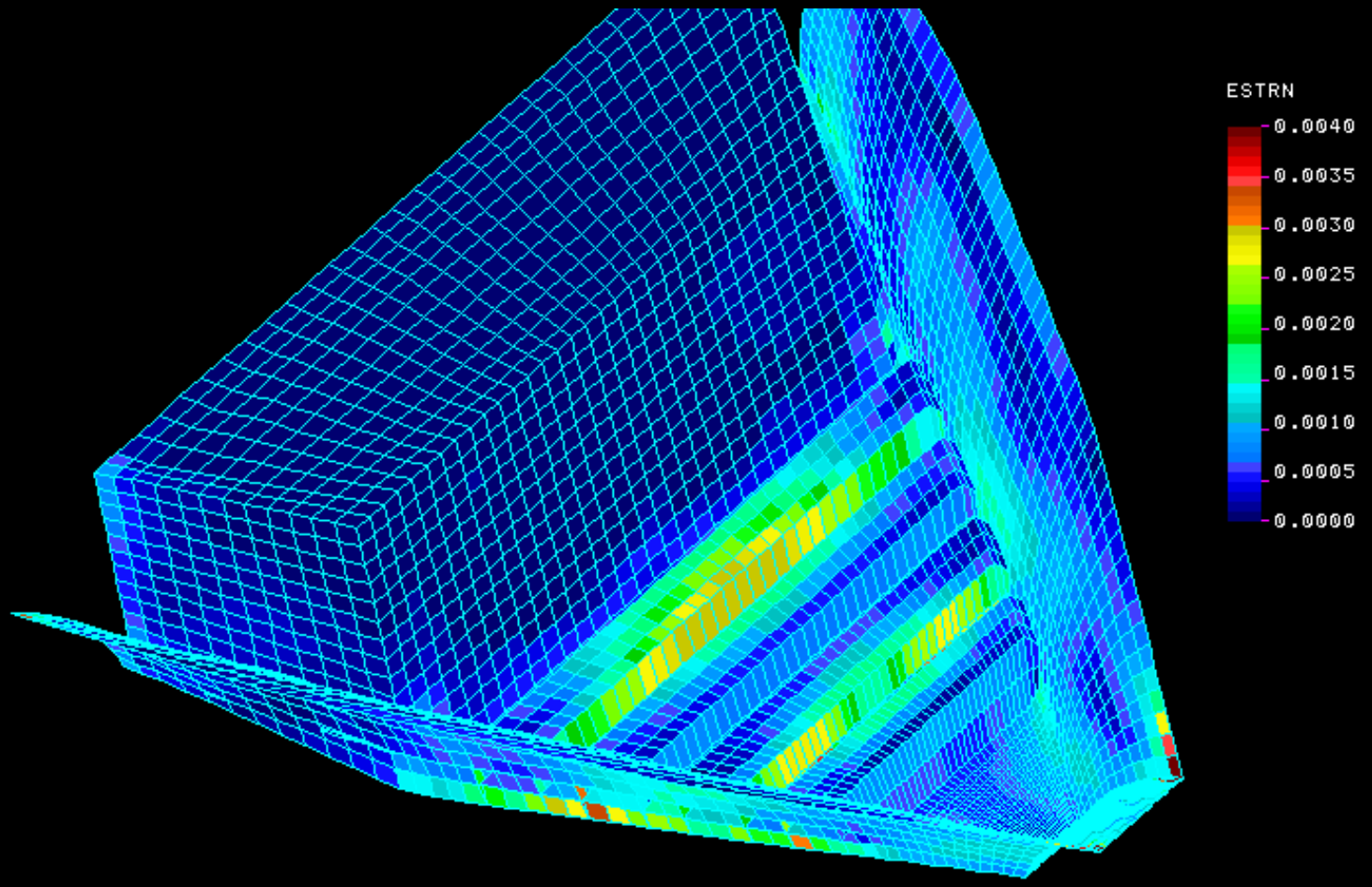
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LC9- GML- Long. Loading Last Layer Strain (Outside View)



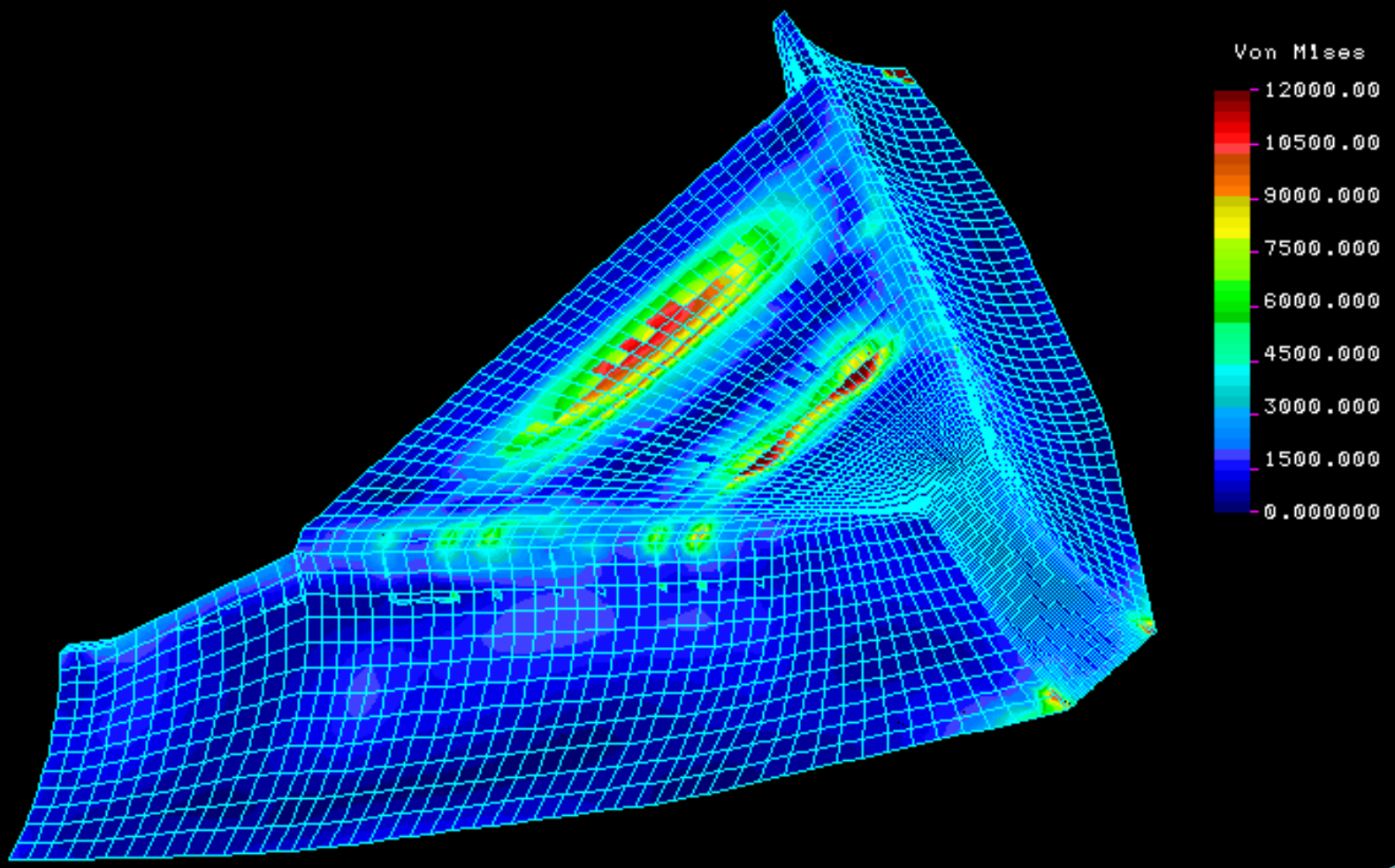
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LC9- GML- Long. Loading Last Layer Strain (Inside View)



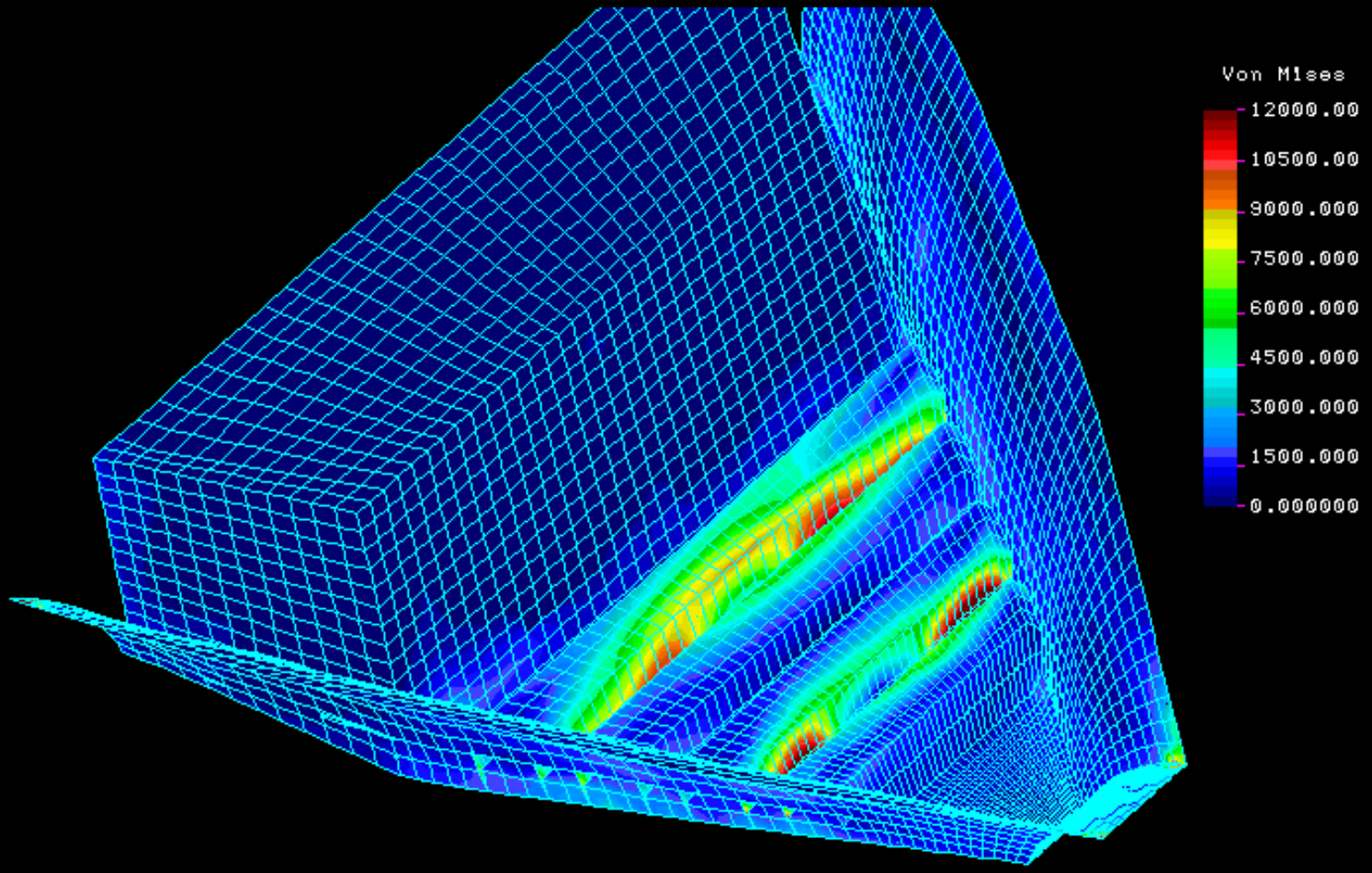
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LC9- GML- Long. Loading Longitudinal Ply Stress (Outside View)



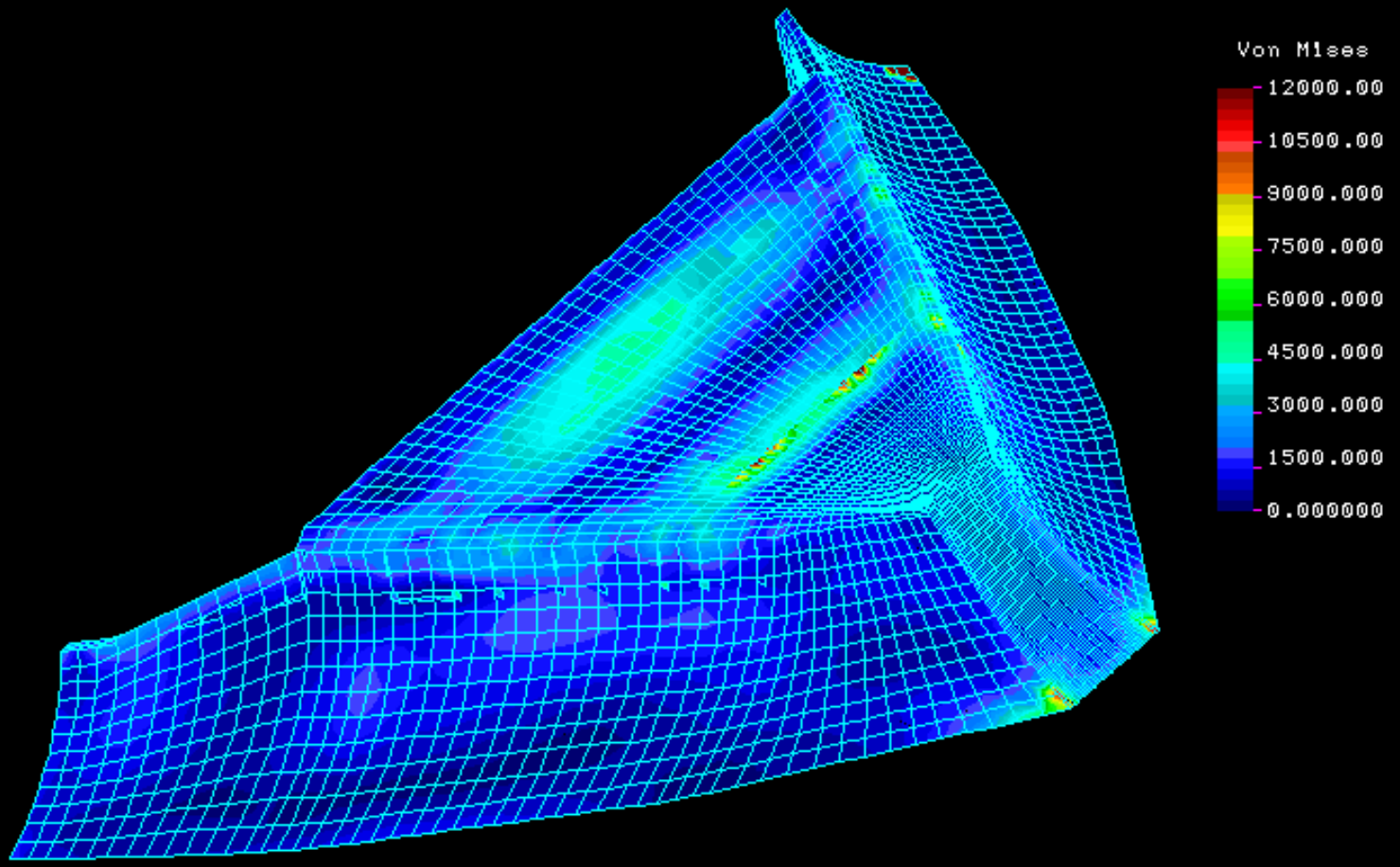
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LC9- GML- Long. Loading Longitudinal Ply Stress (Inside View)



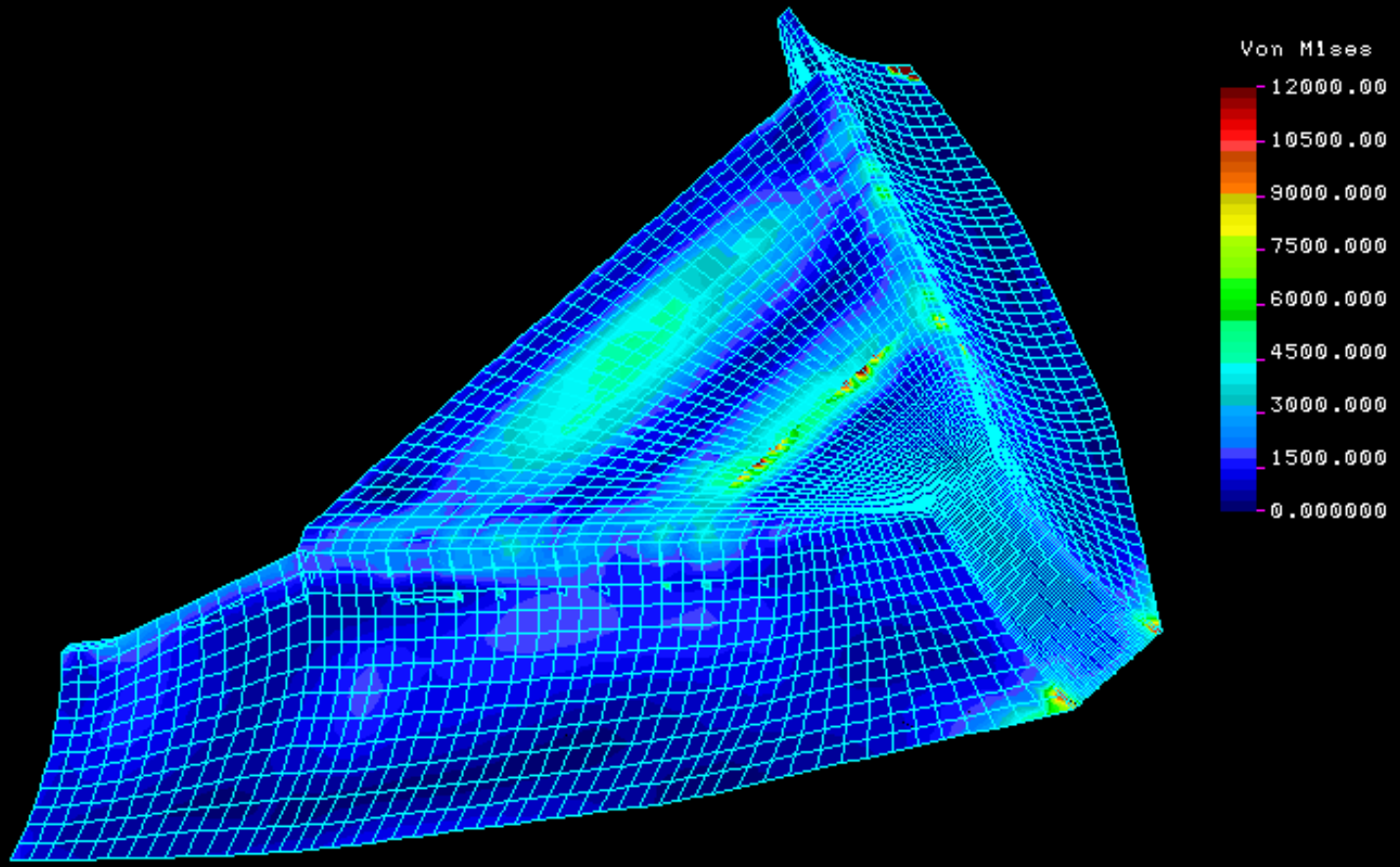
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LC9- GML- Long. Loading Transverse Ply Stresses (Outside View)



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LC9- GML- Long. Loading Transverse Ply Stress (Inside View)



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LC9-11M- G.M.L- Summary

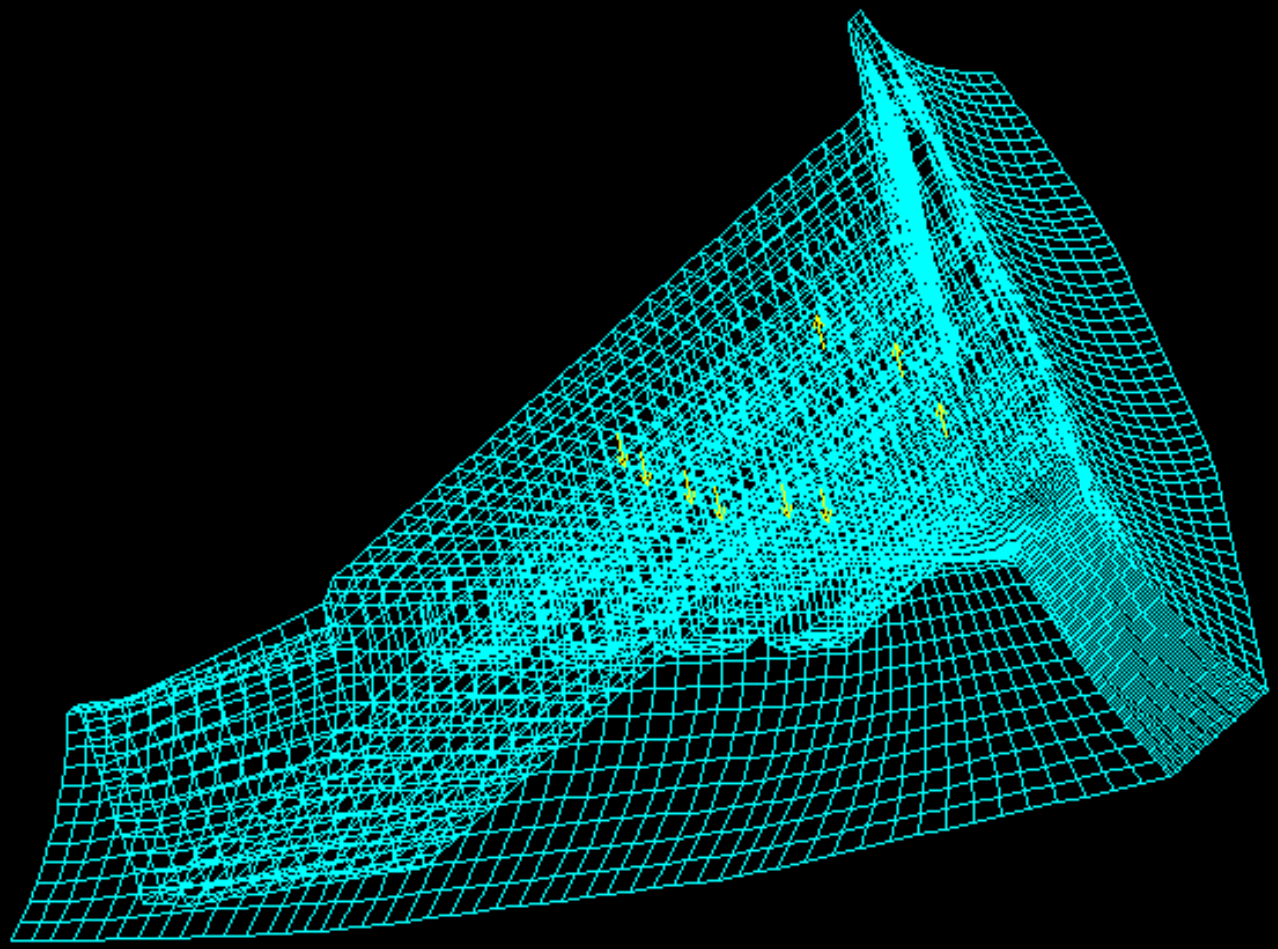
- Range of deflection -.14-.11 in.
- Maximum strain .004 in./in.
- Maximum longitudinal stress 12,000 psi
- Maximum transverse stress 12,000 psi

LC10- GMT- Transverse Loading

Port side
- Three bolts
- Tensile load of 1500 lbs each bolt

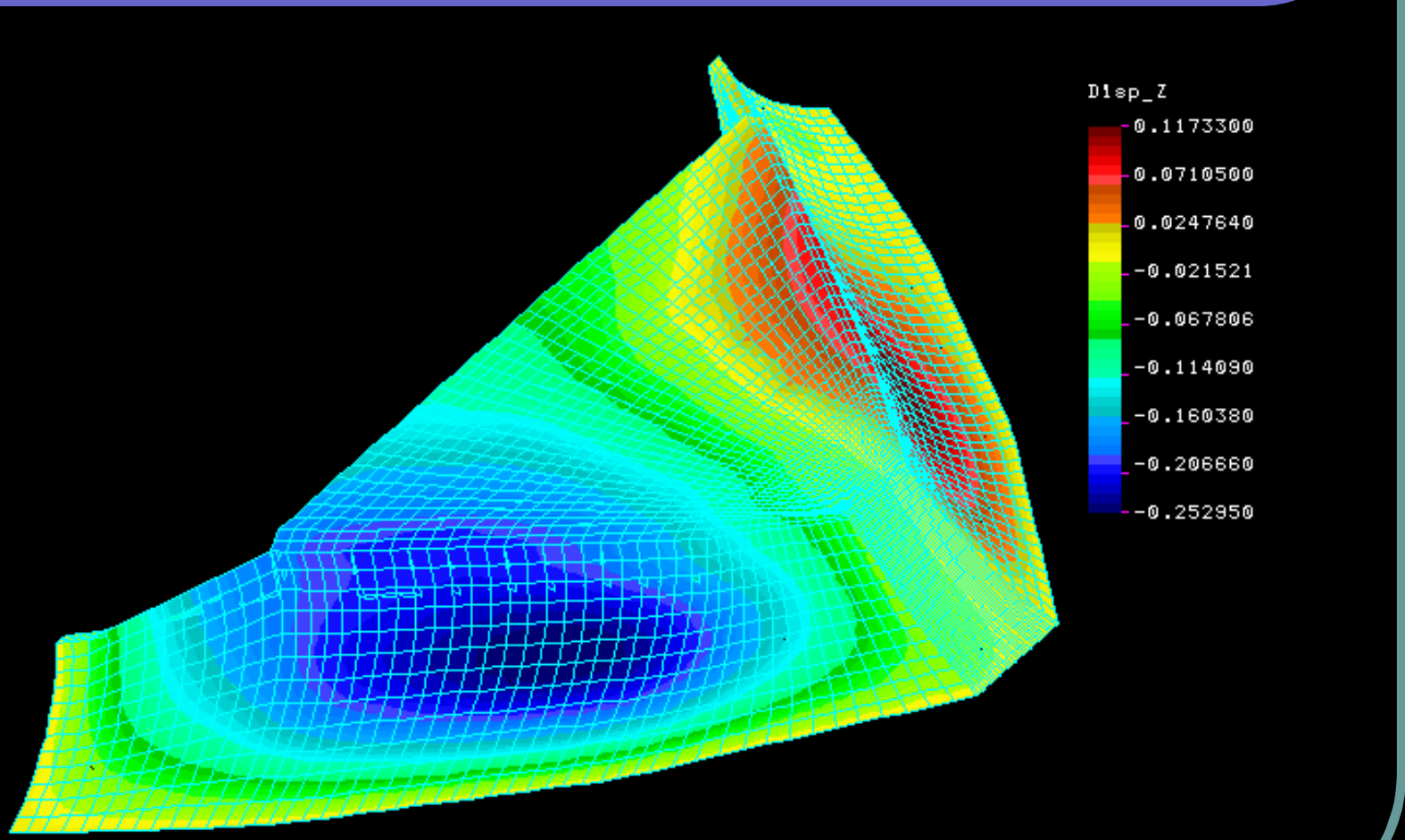
Starboard Side
- Six point loads (where mounting plate edge crosses frame sides)
- Compressive load of 750 lbs each point

LC10- GMT- Trans. Loading



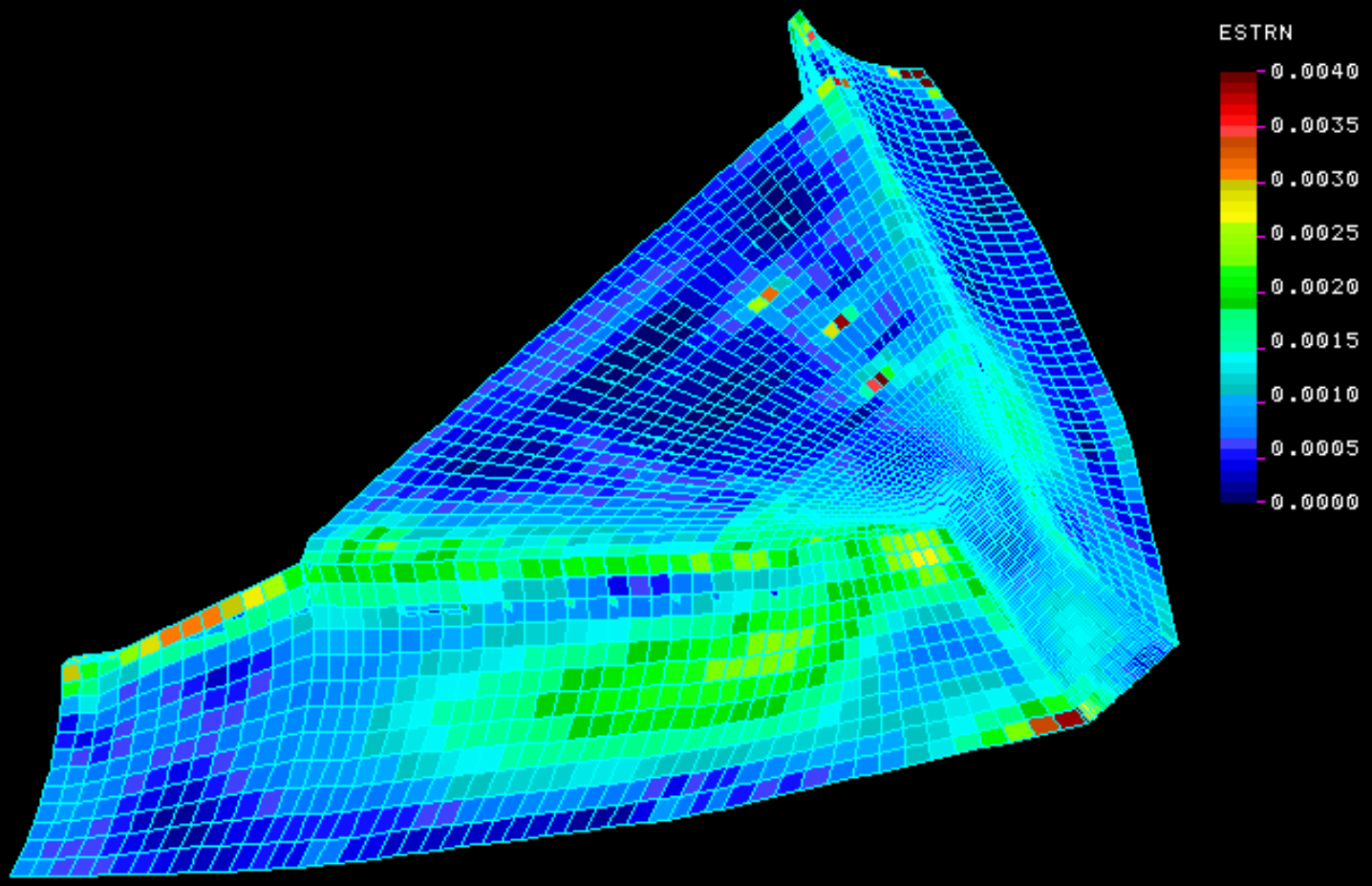
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LC10- GMT- Transverse Loading
Vertical Displacement



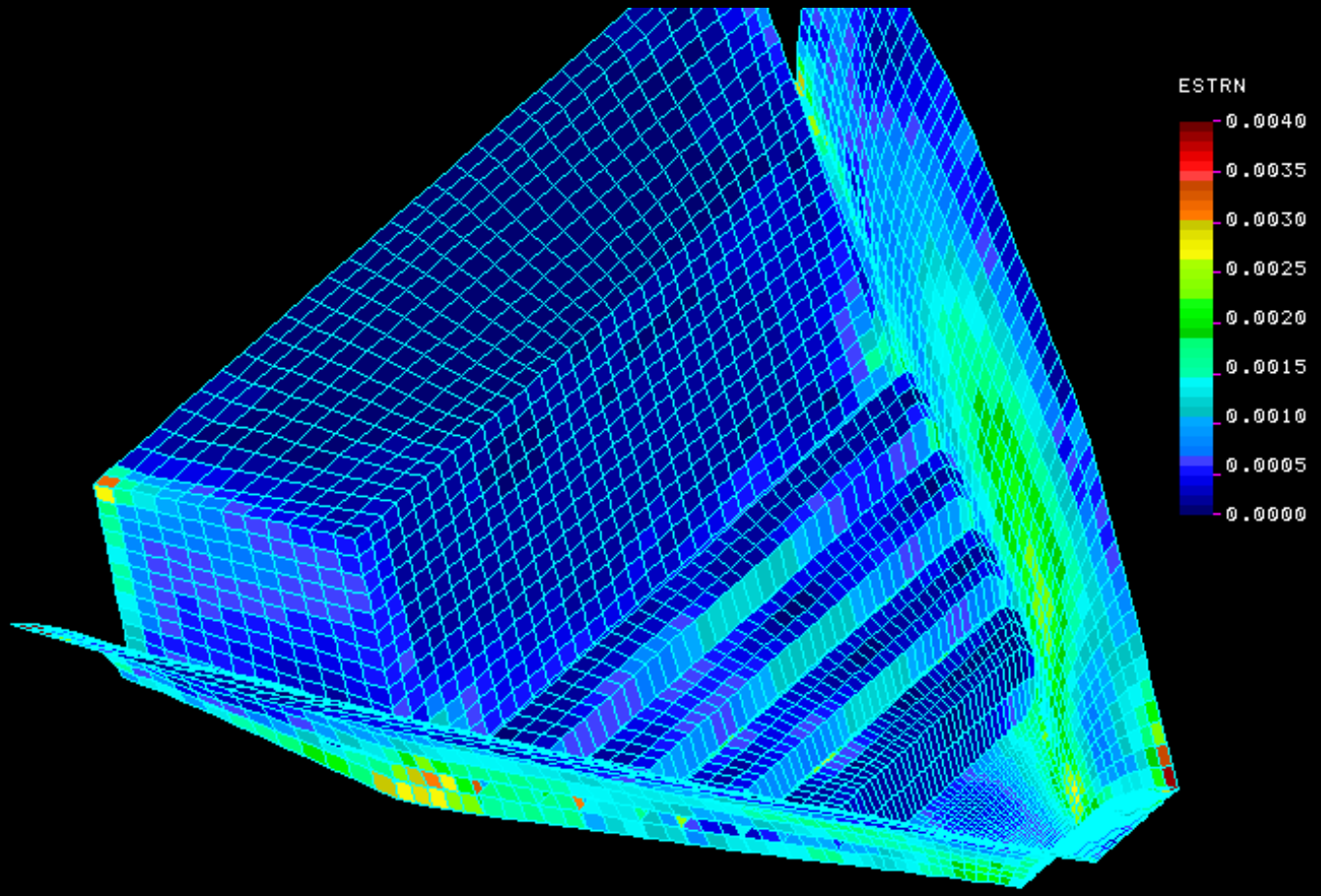
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LC10- GMT- Transverse Loading 1st Layer Strain (Outside View)



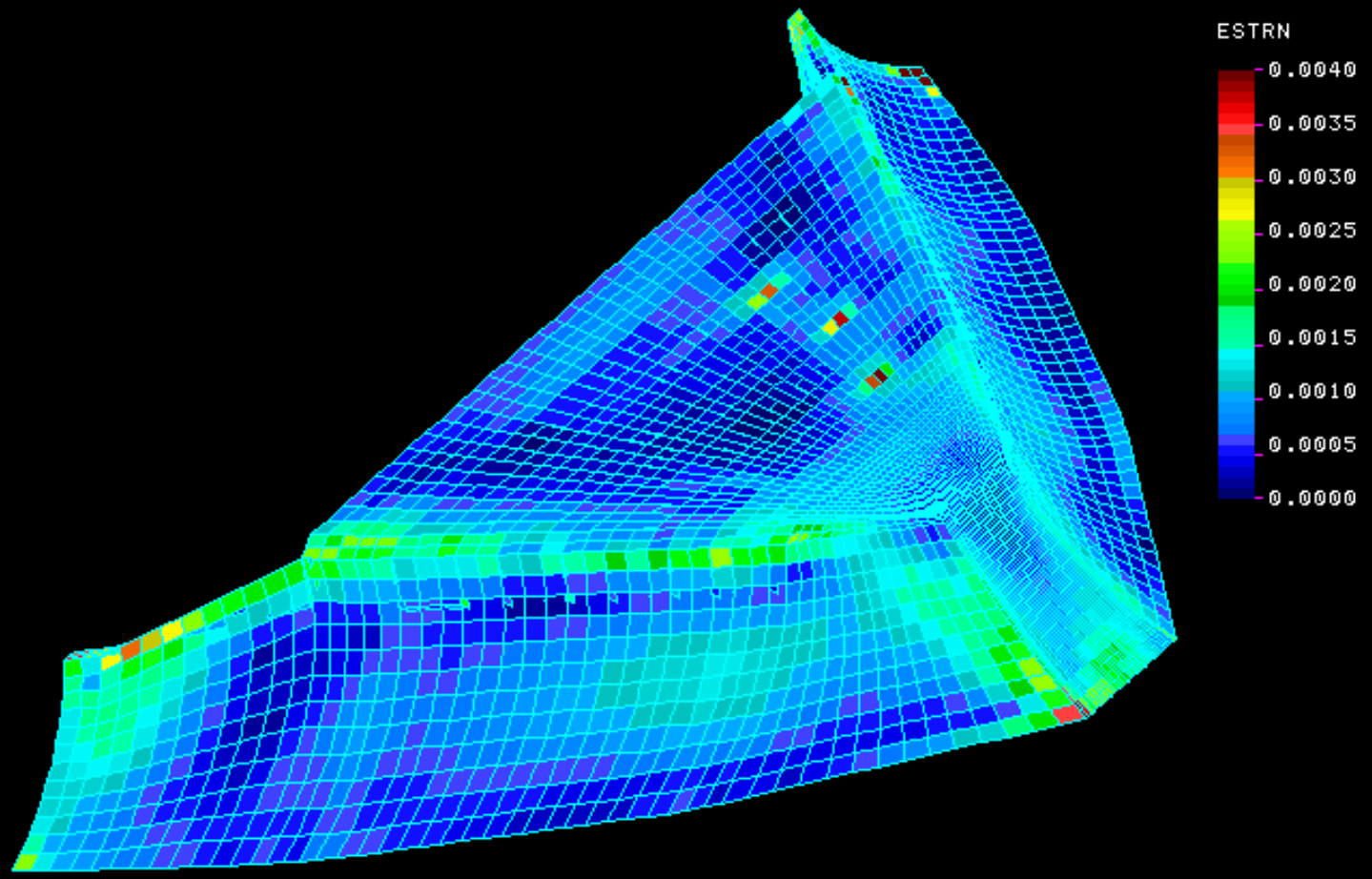
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LC10- GMT- Transverse Loading 1st Layer Strain (Inside View)



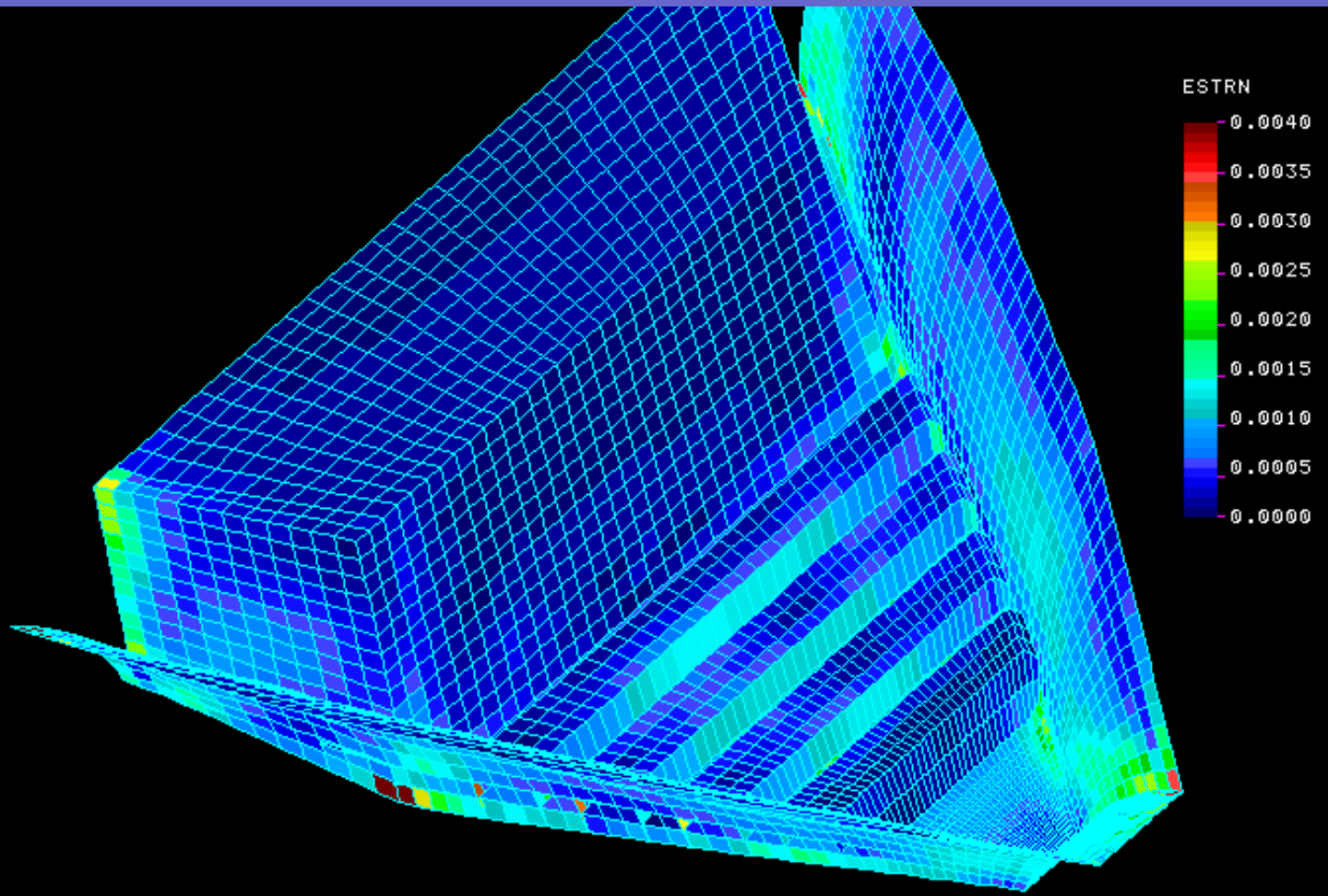
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LC10- GMT- Transverse Loading
Last Layer Strain (Outside View)



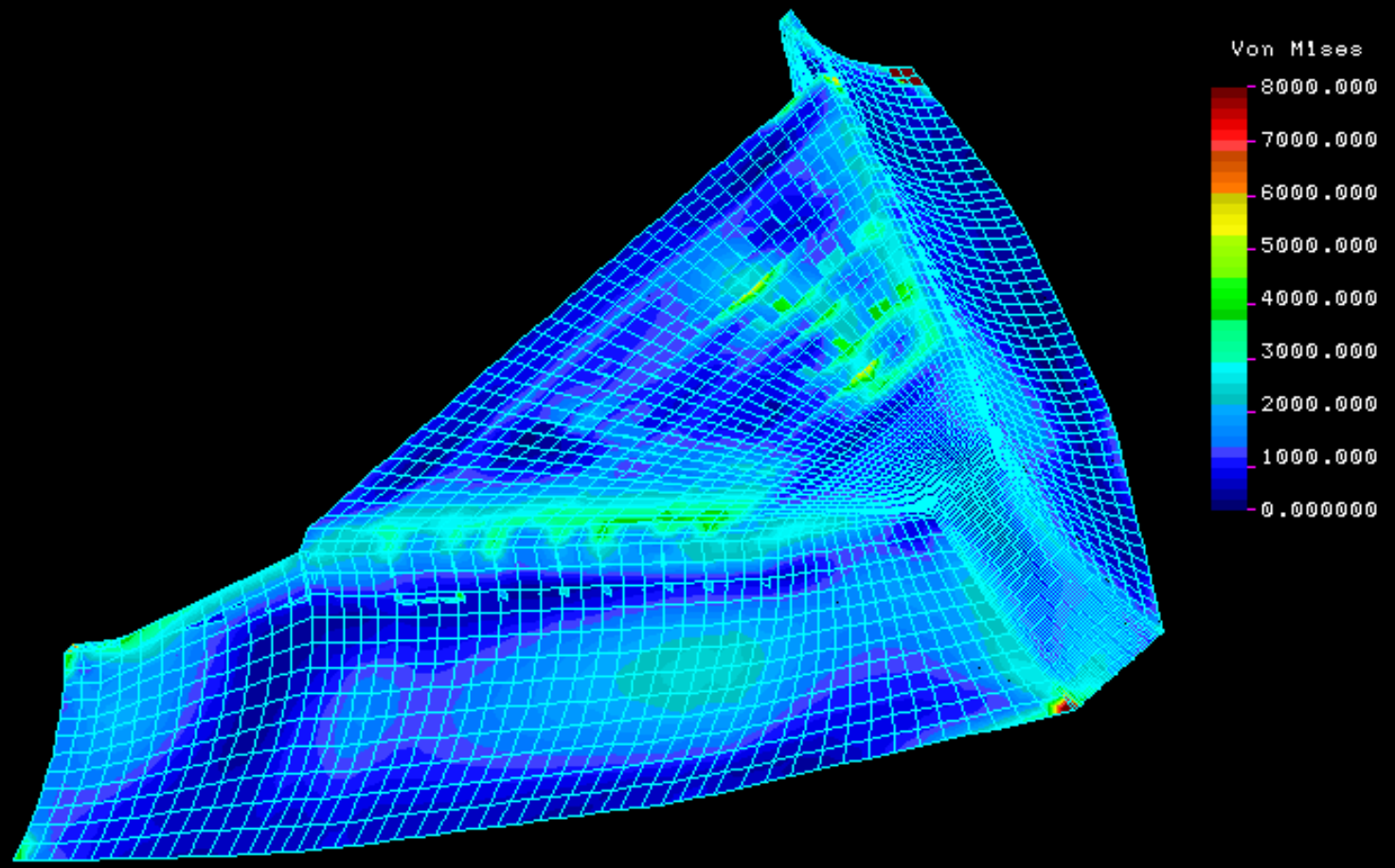
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LC10- GMT- Transverse Loading
Last Layer Strain (Inside View)



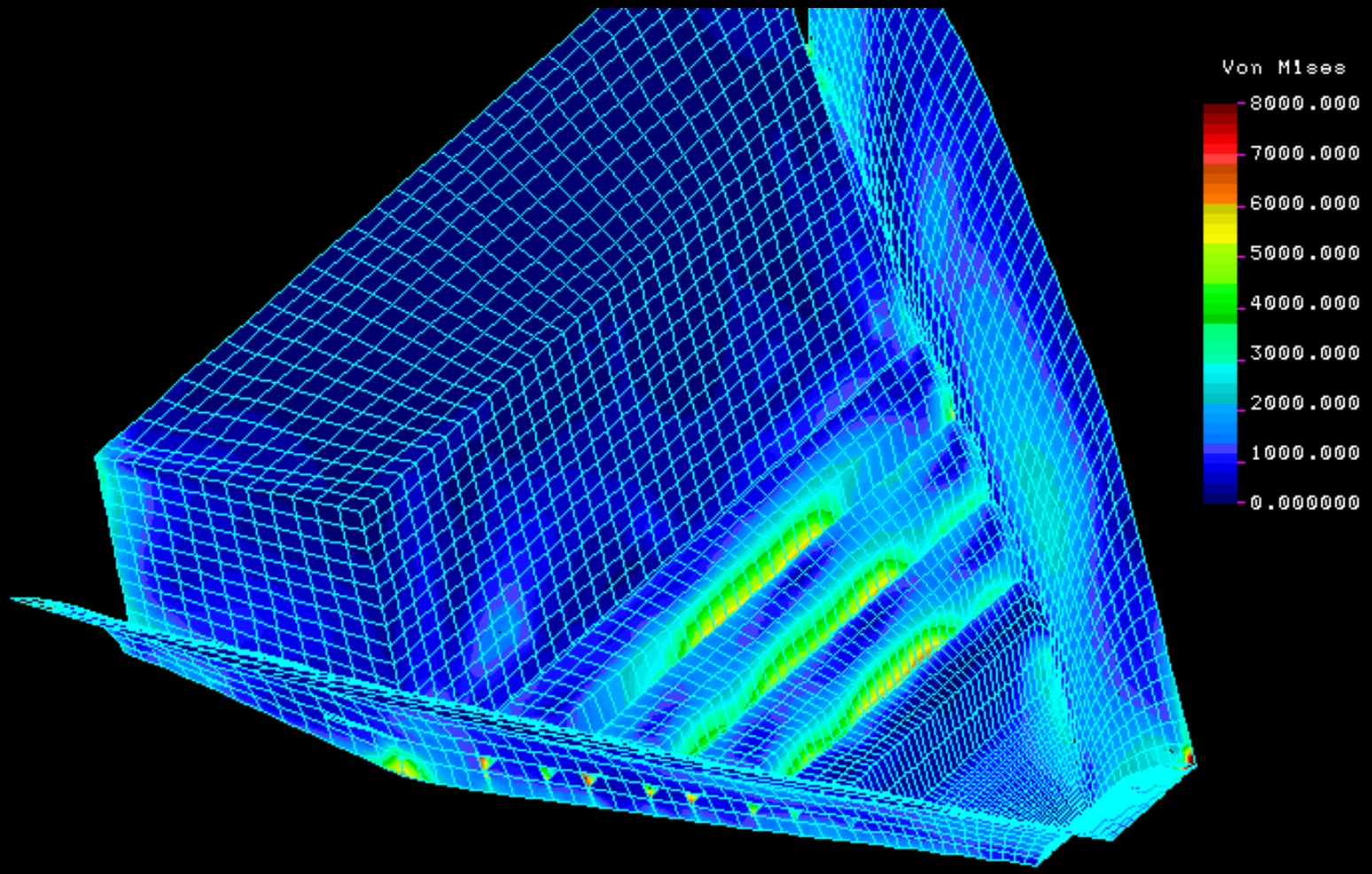
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LC10- GMT- Transverse Loading
Longitudinal Ply Stress (Outside View)



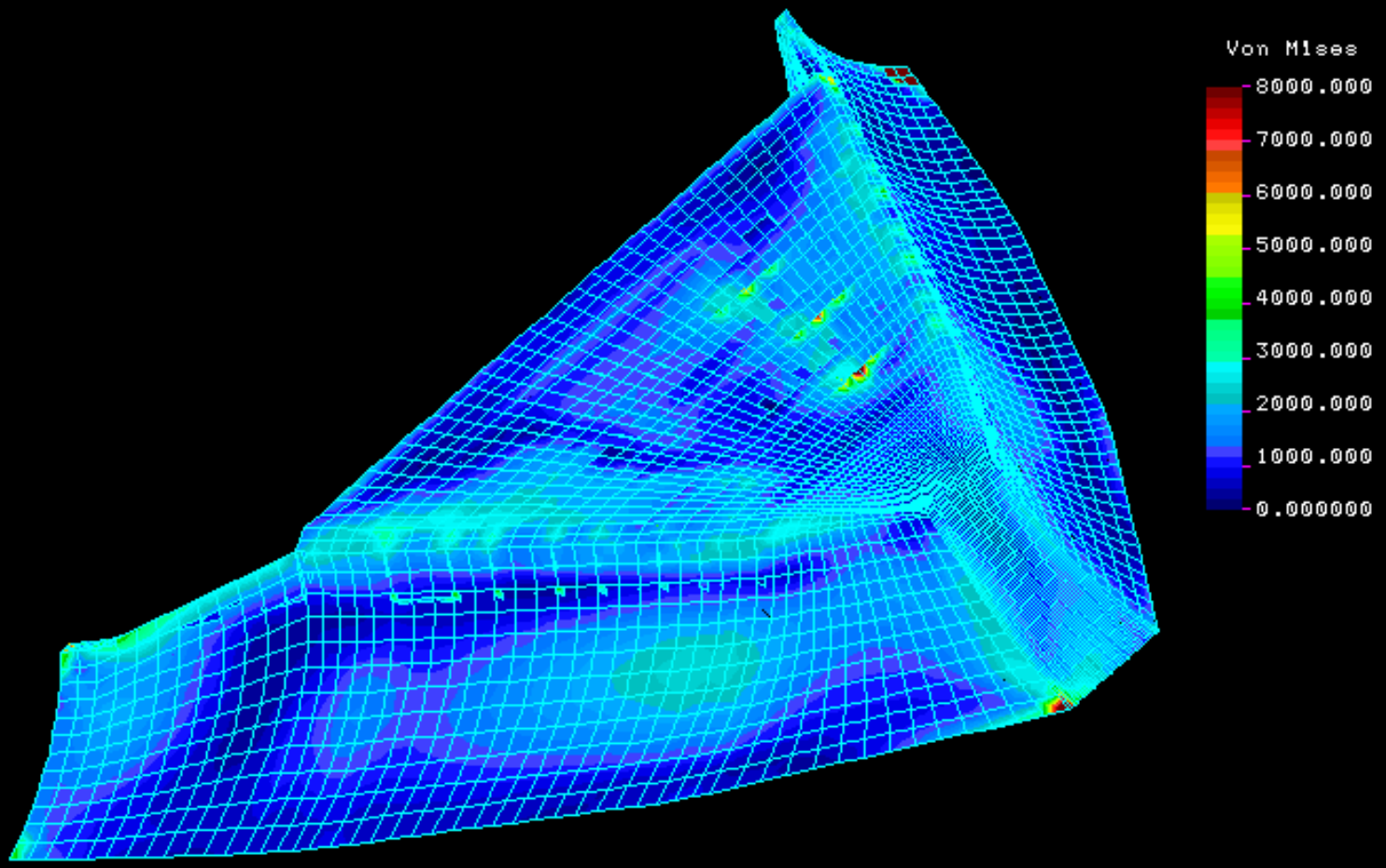
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LC10- GMT- Transverse Loading
Longitudinal Ply Stress (Inside View)



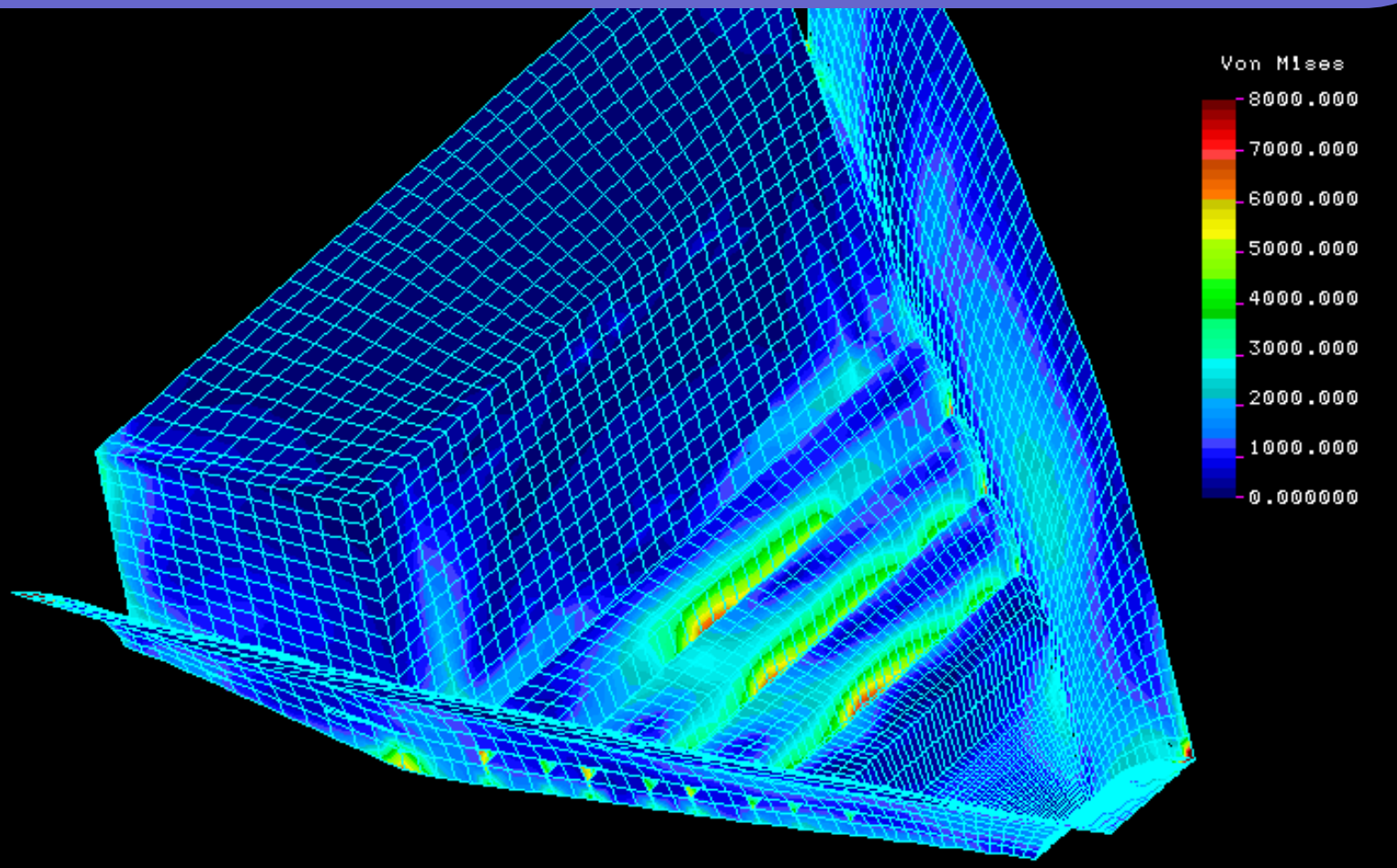
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LC10- GMT- Transverse Loading
Transverse Ply Stresses (Outside View)



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LC10- GMLT- Transverse Loading
Transverse Ply Stress (Inside View)



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LC10- G.M.T- Summary

- Range of deflection -0.25 - 0.18 in.
- Maximum strain 0.004 in./in.
- Maximum longitudinal stress 6,000 psi
- Maximum transverse stress 8,000 psi

179

11M- FEA Analysis: Trailer Load Analysis (TLA)

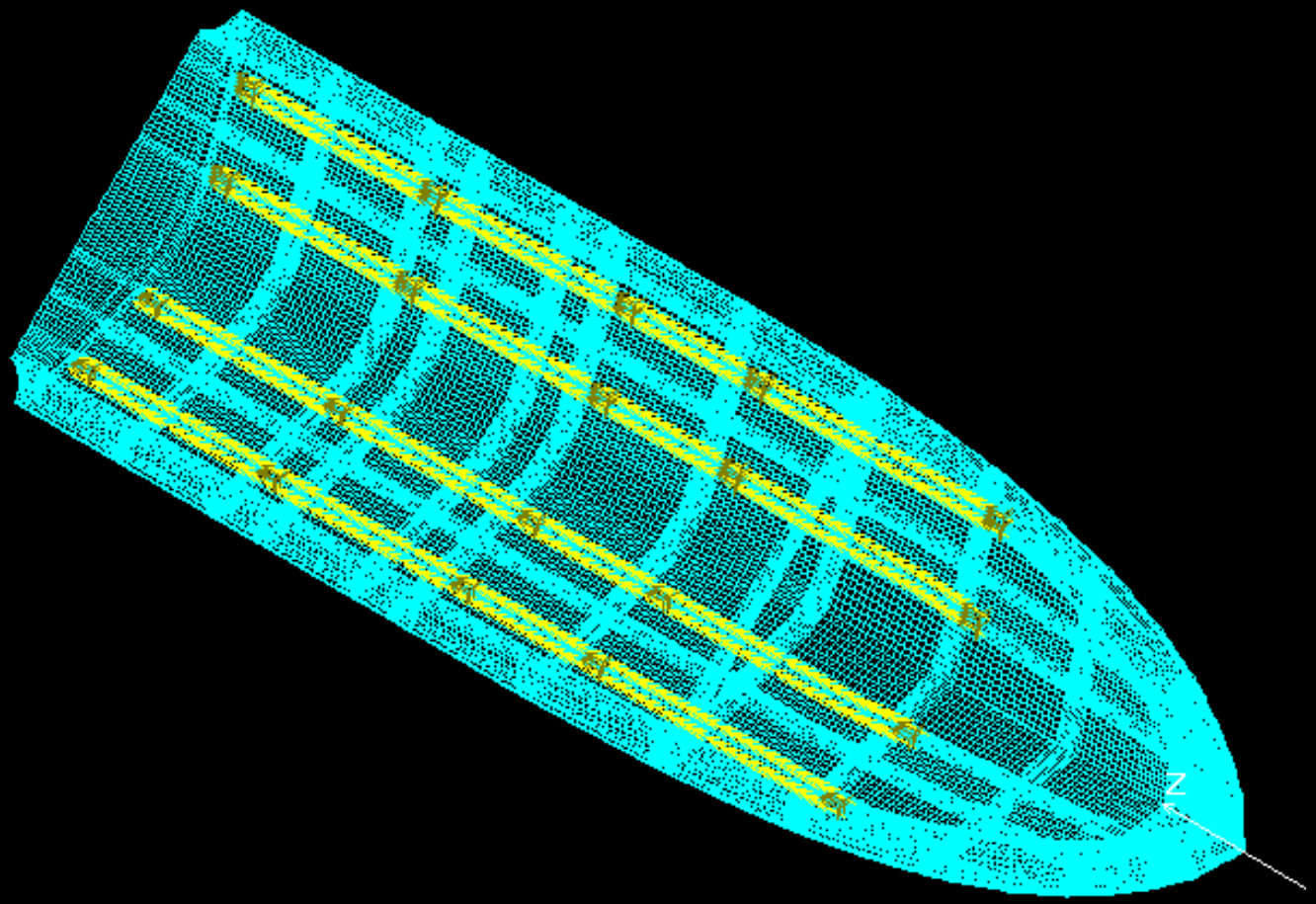


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LC11-AL- Trailer Loads Applied

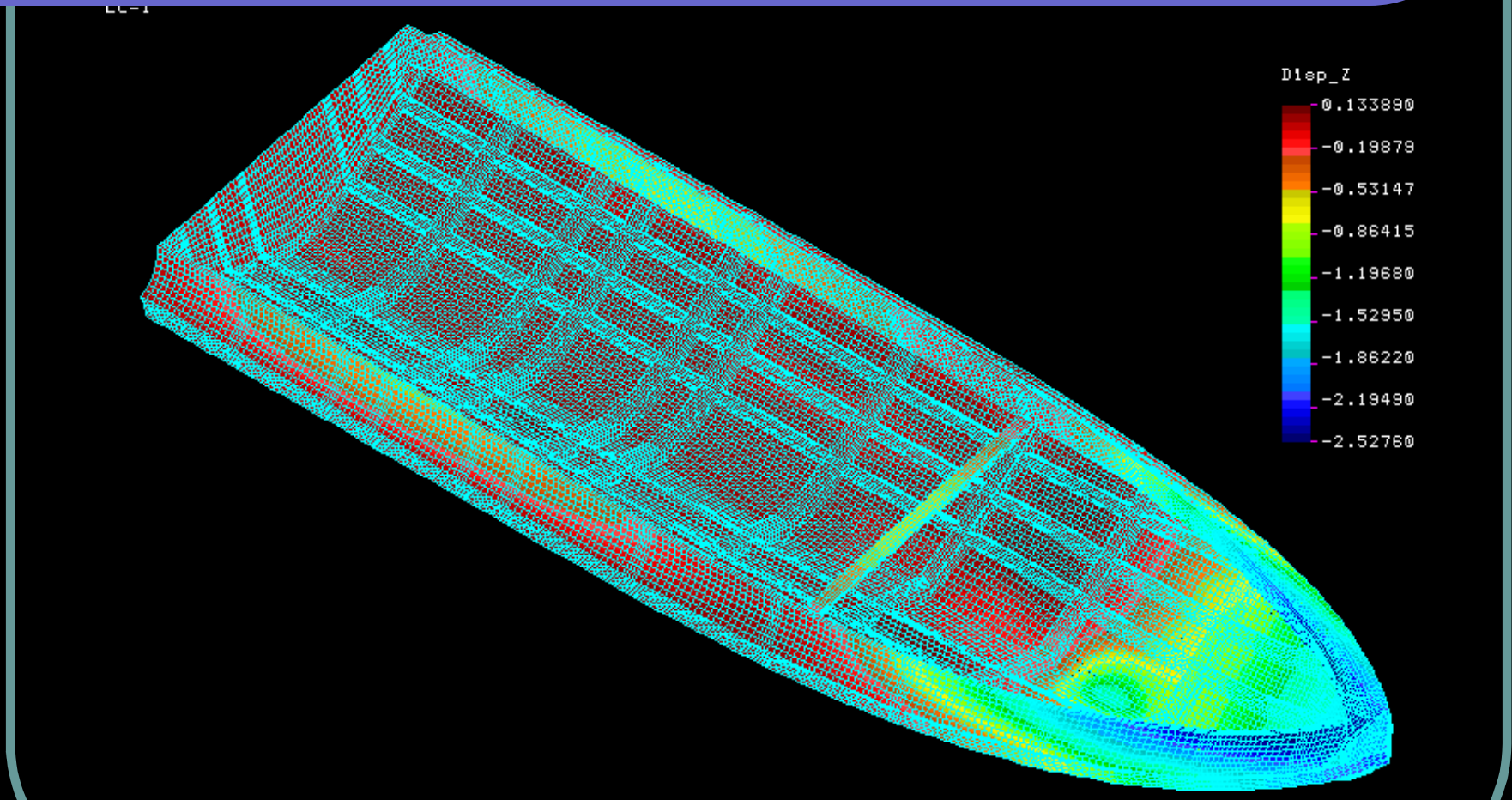
- 3G vertical acceleration (51,000 lbs)
- Weight is uniformly distributed over boat (-1.06 lbs on each node = -51,000 lbs
- Boat is supported by 4 bunks, located under inner and outer stringers on each side
- Bunk support modeled as vertical force applied along bottom side of stringer frames (50 lbs on each of 1008 nodes for 50,400 lbs)
- Bunk supports modeled s vertical constraints (600 lbs total reaction)

LC11-AL- Trailer Loads- Bunk and Loading Constraints



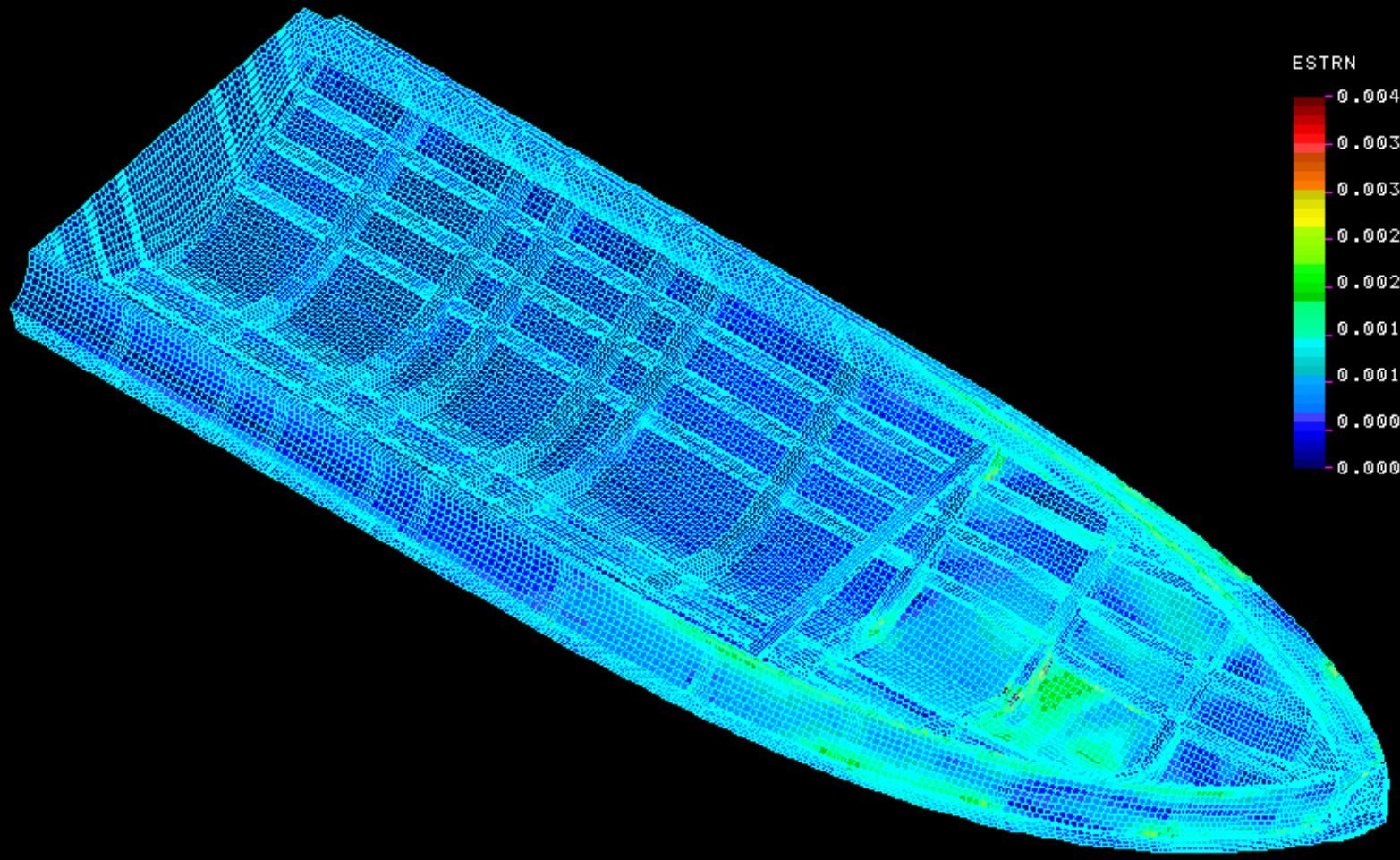
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LC11-AL- TLA- Trailer Loads
Vertical Displacment



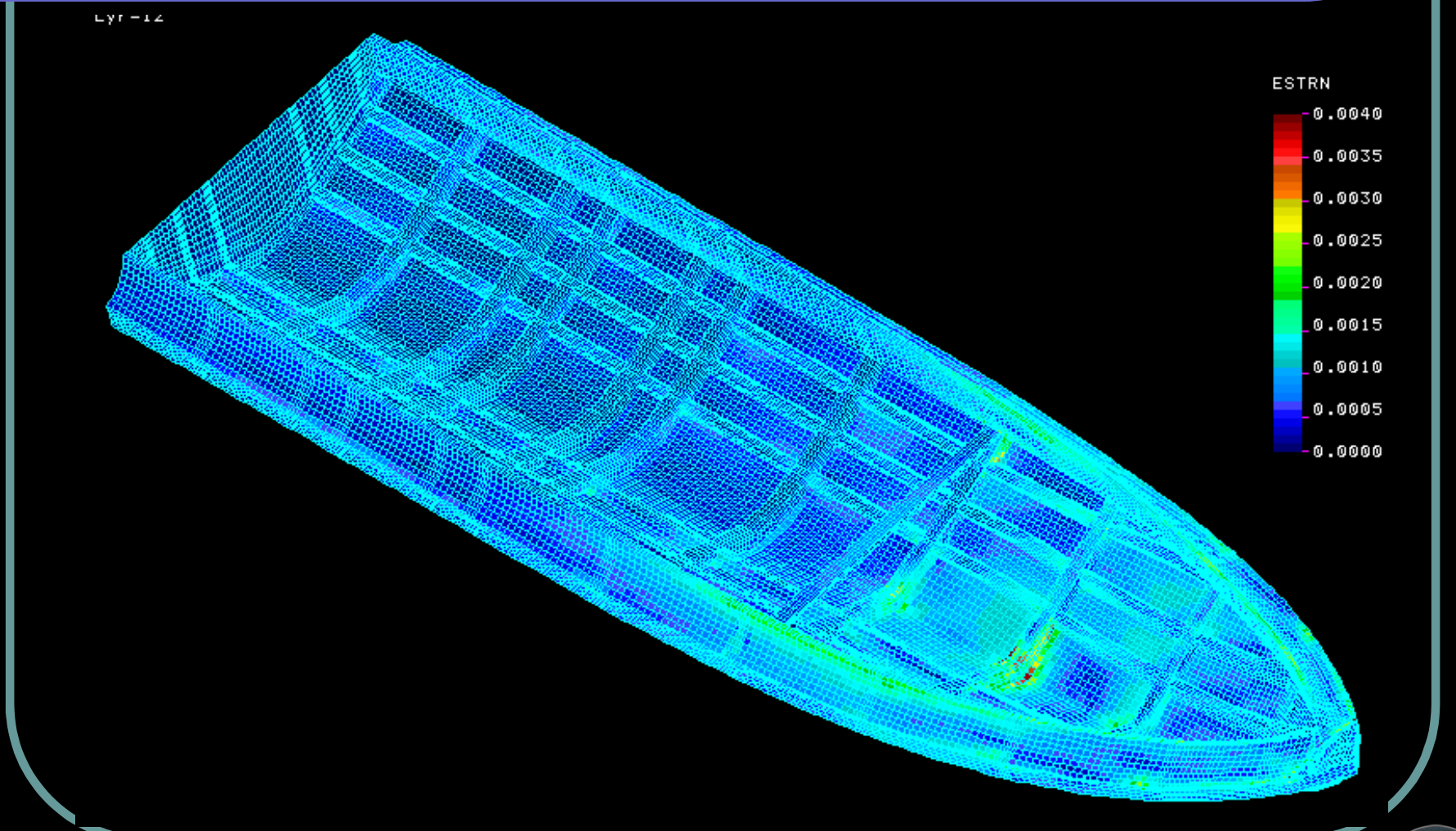
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LC11-AL- TLA- Trailer Loads
Outside Surface Strain



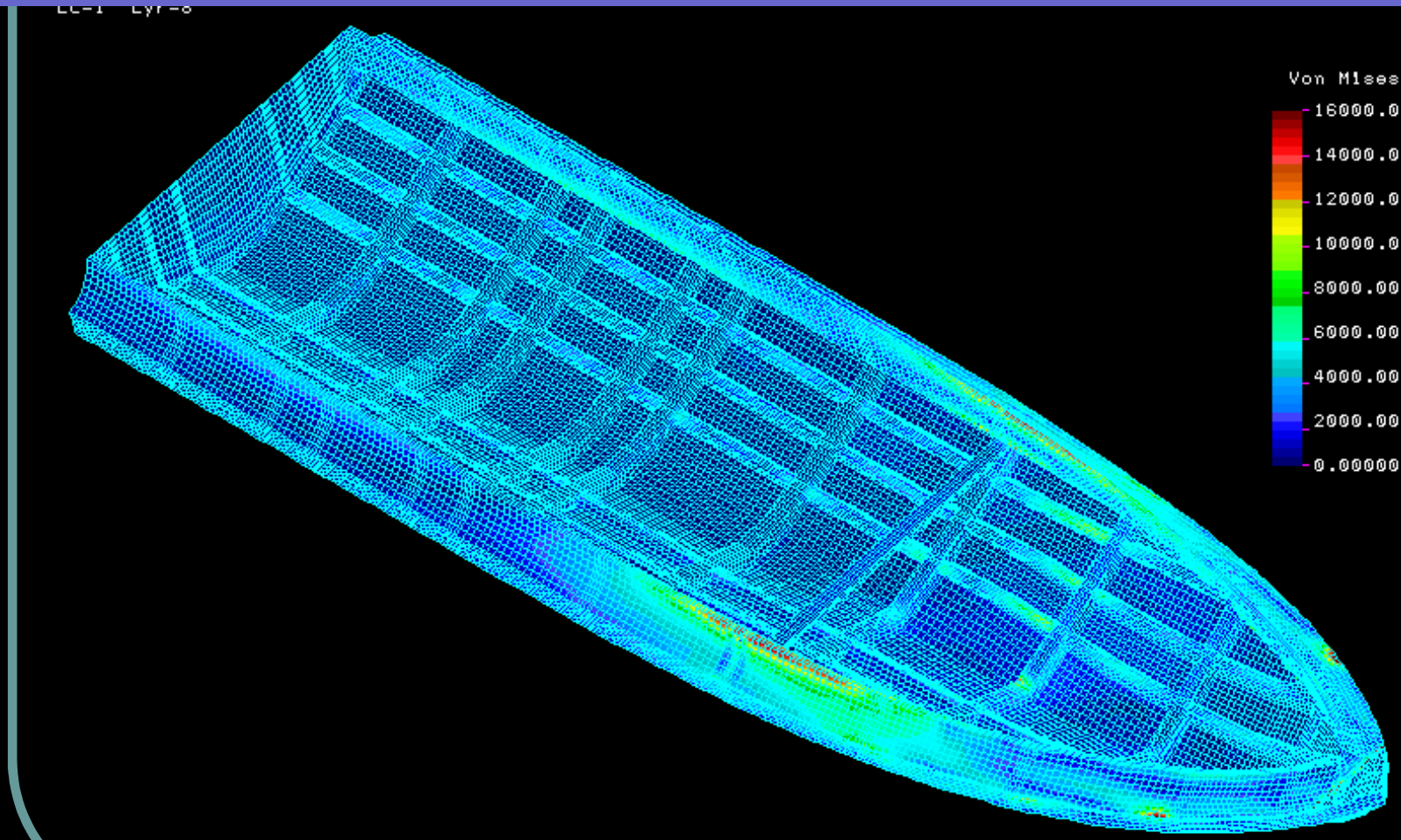
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LC11-AL- TLA- Trailer Loads
Inside Surface Strain



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LC11-AL- TLA- Trailer Loads Longitudinal Stress



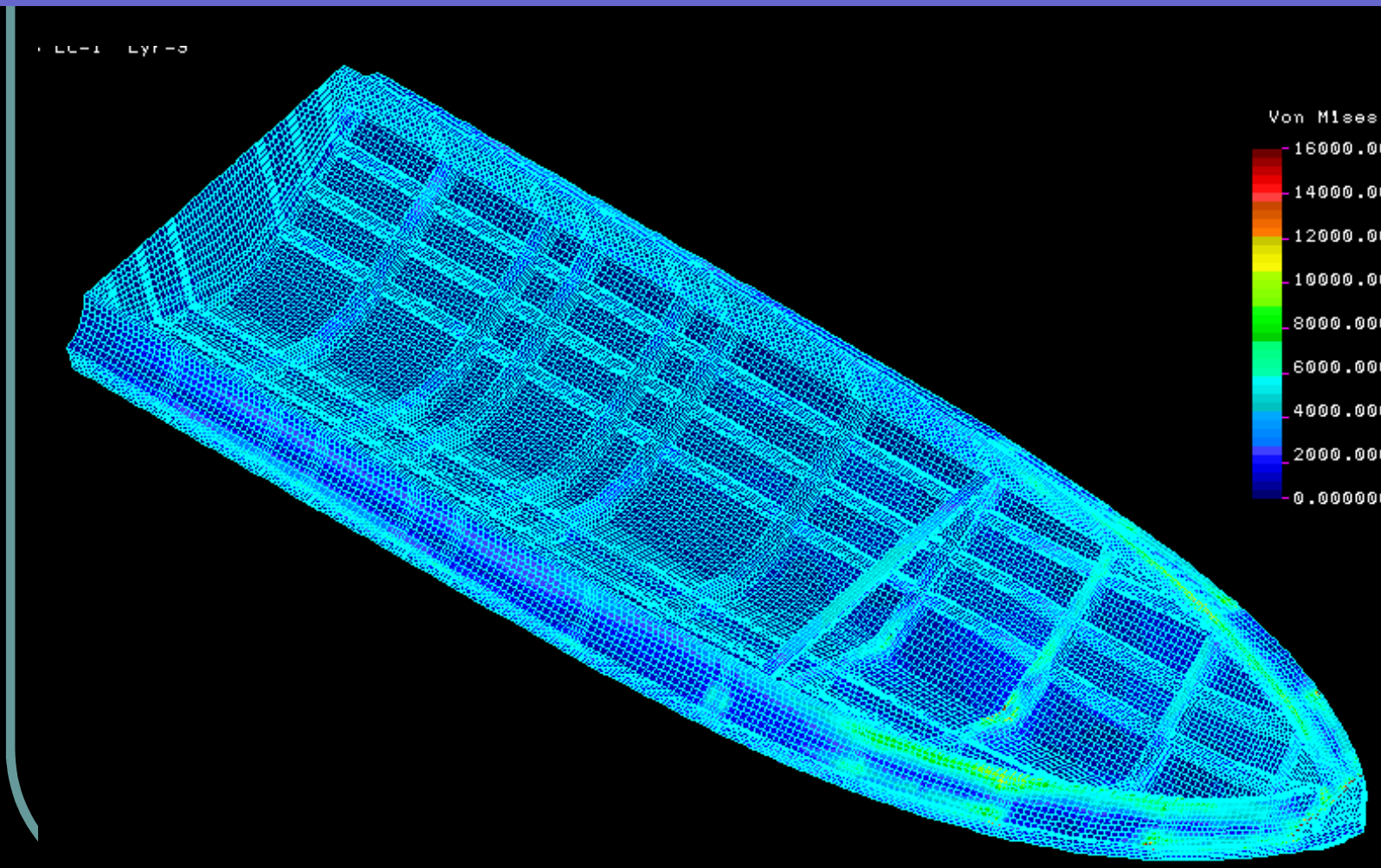
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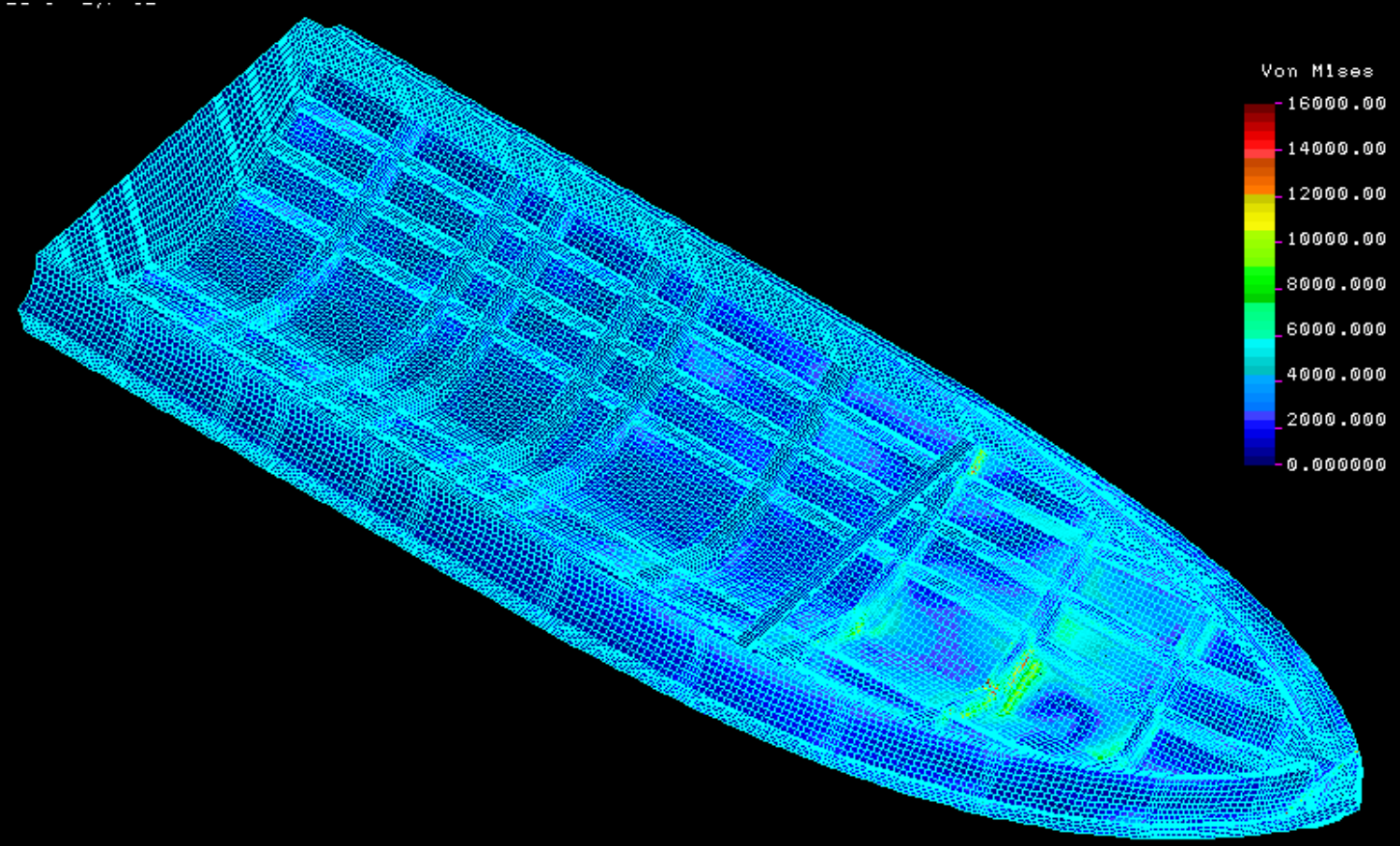
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LC11-AL- TLA- Trailer Loads Transverse Stress



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LC11-AL- TLA- Trailer Loads



LC11-AL- TLA Summary

- Structural Analysis for 3 G “hit” while traveling on trailer
- Stresses and strains are low except at the forward end of the support bunk, where a minimum safety factor of 8 (i.e. a 24 G acceleration is required to break the boat structure)

11M-AL - LC11- TLA Summary

- Range of deflection to -2.5 in to 0.13 in.
- Maximum hull strain 0.004 in/in
- Maximum framing stress 15,000 psi

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 11M- Exceeds Metrics, On Target

Weight Evaluation Advanced and FG

Component	Al- Weight(lb)	FG-Weight (lb)
Hull	930-960	1070-1100
Deck	470-490	470-490

Total Weight Hull, and Deck	**1400-1450 55% to 57% Savings from Baseline**	**1540 - 1590 50 to 53% Savings from Baseline**

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 11M- Exceeds Metrics, On Target

11M Conclusions

- Both Advanced and Fiberglass designs are adequate
- Both Designs Exceed Weight Reduction Goal
- Fiberglass Design Chosen For Rapid Implementation- Lower Risk
- Advanced Design recommended if Navy Desires to advance new materials- Higher Risk

Lightweight Shock Mitigation in Naval RIB Hull Structures Fiberglass Design

SCRA Subcontract #2011-510

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11M DESIGN REVIEW
November 2012

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11M Design Presentation – Fiberglass Design

- 11M Drawing Package
  - Hull
  - Deck
- 11M Structural Analysis
  - Wave Load FEA (Advanced and FG variants)
  - Gun Mount FEA
  - Lift Load FEA (Advanced and FG variants)
  - Trailer Load FEA (Advanced and FG variants)
- 11M Weight Estimates
- 11M Conclusions

11M- Drawings Package Fiberglass Design



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11M – Laminate Schedule – Fiberglass Design

- Hull – Gel Coat, 2oz CSM, E BXM 2408 (in strakes only), FS2010, 2 x E LTM 3610
- Stringers – TR4030X, 3 x E LM 1810, E BXM 1208
- Bulkheads/Bulkhead Wings – Custom Prisma, 3 x E LM 1810 (3in wide), E BXM 1208
- Deck – Gel Coat / 2oz CSM, 2 x E LTM 1808
- Deck Framing – TR4030 (24oz 0/90), E LM 1810 uni
- Transom – Gel Coat , 2oz CSM, 1 x E LT 3610, Transom Preforms (24oz +/-45, bottom overlays (2 x E LM 1810), 1 x E LTM 3610

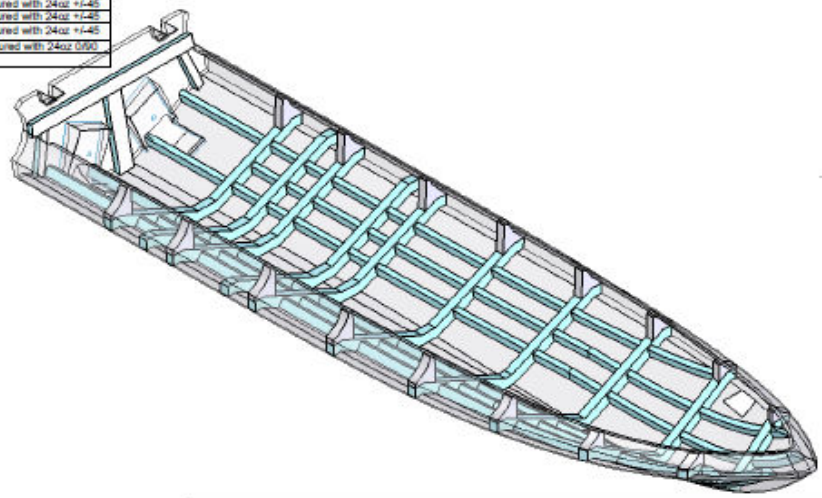
11M- Hull Drawings – Fiberglass Design

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33UE-2435 UB Grey	
2	A/R	Resin	Interplastic	CORVE 8106	
3	A/R	Resin	Interplastic	CORVE 8123	
4	A/R	2oz Chopped Strand Mat			
5	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
6		not used			
7	A/R	E-BXM 2408 +/-45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	A/R	E-BXM1715 +/-45 fabric - 3" wide	Vectorply	E-BXM1715	+/-45 fabric
11		not used			
12	75 LF	TR4040X	Compsys	TR4030X	manufactured with 24oz +/-45
13	1	Starboard Mid Stringer	Compsys	ZDC11M-SPMS	manufactured with 24oz +/-45
14	1	Starboard Inboard Stringer	Compsys	ZDC11M-SPIS	manufactured with 24oz +/-45
15	1	Port Mid Stringer	Compsys	ZDC11M-PPMS	manufactured with 24oz +/-45
16	1	Port Inboard Stringer	Compsys	ZDC11M-PPIS	manufactured with 24oz +/-45
17		not used			
18	2 LF	TR3726X	Compsys	TR3726X	manufactured with 24oz +/-45
19	5 LF	TR6026X	Compsys	TR6026X	manufactured with 24oz +/-45
20	15 LF	TR6026X	Compsys	TR6026X	manufactured with 24oz +/-45
21	1	Bulkhead A	Compsys	ZDC11M-BH10	manufactured with 24oz +/-45
22	1	Bulkhead B	Compsys	ZDC11M-BH09	manufactured with 24oz +/-45
23	1	Bulkhead C	Compsys	ZDC11M-BH08	manufactured with 24oz +/-45
24	1	Bulkhead D	Compsys	ZDC11M-BH07	manufactured with 24oz +/-45
25	1	Bulkhead E	Compsys	ZDC11M-BH06	manufactured with 24oz +/-45
26	1	Bulkhead F	Compsys	ZDC11M-BH05	manufactured with 24oz +/-45
27	1	Bulkhead G	Compsys	ZDC11M-BH04	manufactured with 24oz +/-45
28	1	Bulkhead H	Compsys	ZDC11M-BH03	manufactured with 24oz +/-45
29	1	Bulkhead I	Compsys	ZDC11M-BH02	manufactured with 24oz +/-45
30	1	Bulkhead J	Compsys	ZDC11M-BH01	manufactured with 24oz +/-45
31	100 LF	FS2010	Compsys	FS2010	manufactured with 24oz 0/90
32	A/R	1/2" PVC SCH 80		1/2" PVC	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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DRAWING TITLE

11M DESIGN 1 - HULL

DATE 10/24/2012
DRAWN TSS BALTAZAR
CHKD/GD XXXXXXXXXX
APRVD XXXXXXXXXX
SCALE: NTS | JOB No. | DWG No. xxxx-11M-1 | SHEET 1 OF 7 | REV

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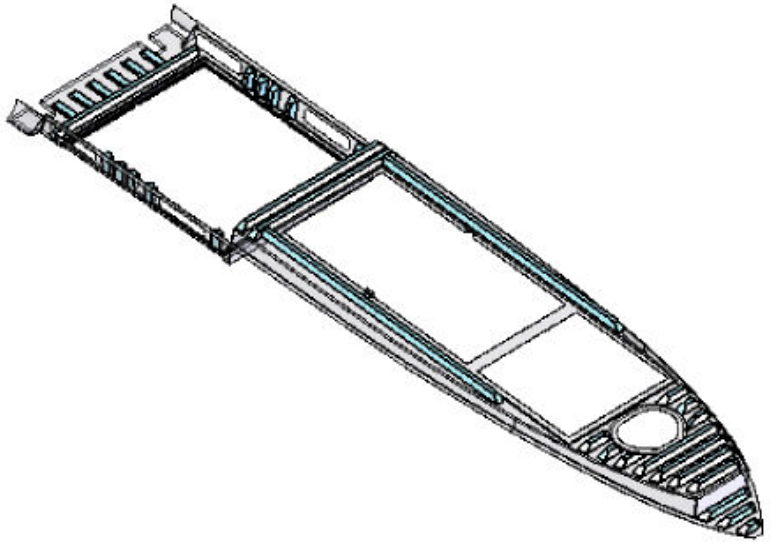
11M- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	Resin	Interplastic	CORVE 8106	
3		not used			
4	A/R	2oz Chopped Strand Mat			
5		not used			
6	A/R	E-BXM1208 +/- fabric	Vectorply	E-BXM 1208	+/- fabric
7	A/R	2308BX	Vectorply	2308BX	
8	A/R	E-LTM 1808 0/90 fabric	Vectorply	E-LTM-1808	0/90 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	80 LF	TR4030	Compsys	TR4030	manufactured with 24oz 0/90
11	10 LF	TR4010	Compsys	TR4010	manufactured with 24oz 0/90
12		not used			
13		not used			
14		not used			
15		not used			

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
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SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 1 OF 3

STRUCTURAL COMPOSITES® LOCKHEED MARTIN ATI ZODIAC®

11M- FEA Analysis – Fiberglass Design



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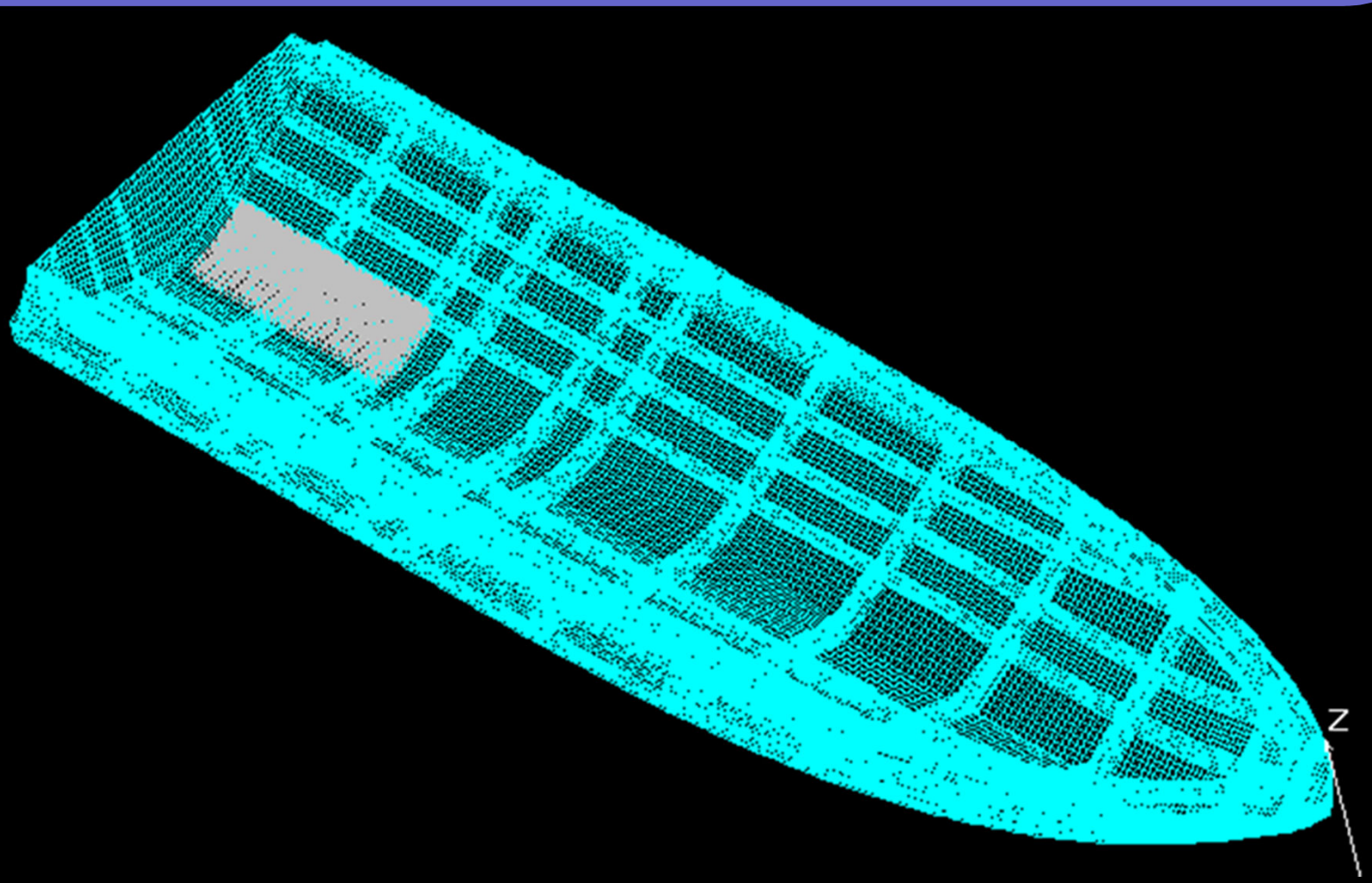
11M Fiberglass Design- FEA Load Cases

Load Case	Load ID	Description	Pressure	Load lb
1	AI	Aft Inboard, SAS	10psi	--
2	AO	Aft Outboard, SAS	10psi	--
3	AMI	Aft Mid Inboard, SAS	10psi	--
4	AMO	Aft Mid Outboard, SAS	10psi	--
5	FMI	Fwd Mid Inboard, SAS	10psi	--
6	FMO	Fwd Mid Outboard, SAS	10psi	
7	FI	Fwd, Inboard	10psi	
8	BLP	Boat Lift Points	--	105,600
9 **10**	GML GMT	Gun Mount-Longitudinal Transverse	--	
11	TLR	Trailer Analysis	--	51000

Small Area Pressure Load

- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

LC1-FG- AI-10 psi Pressure Load

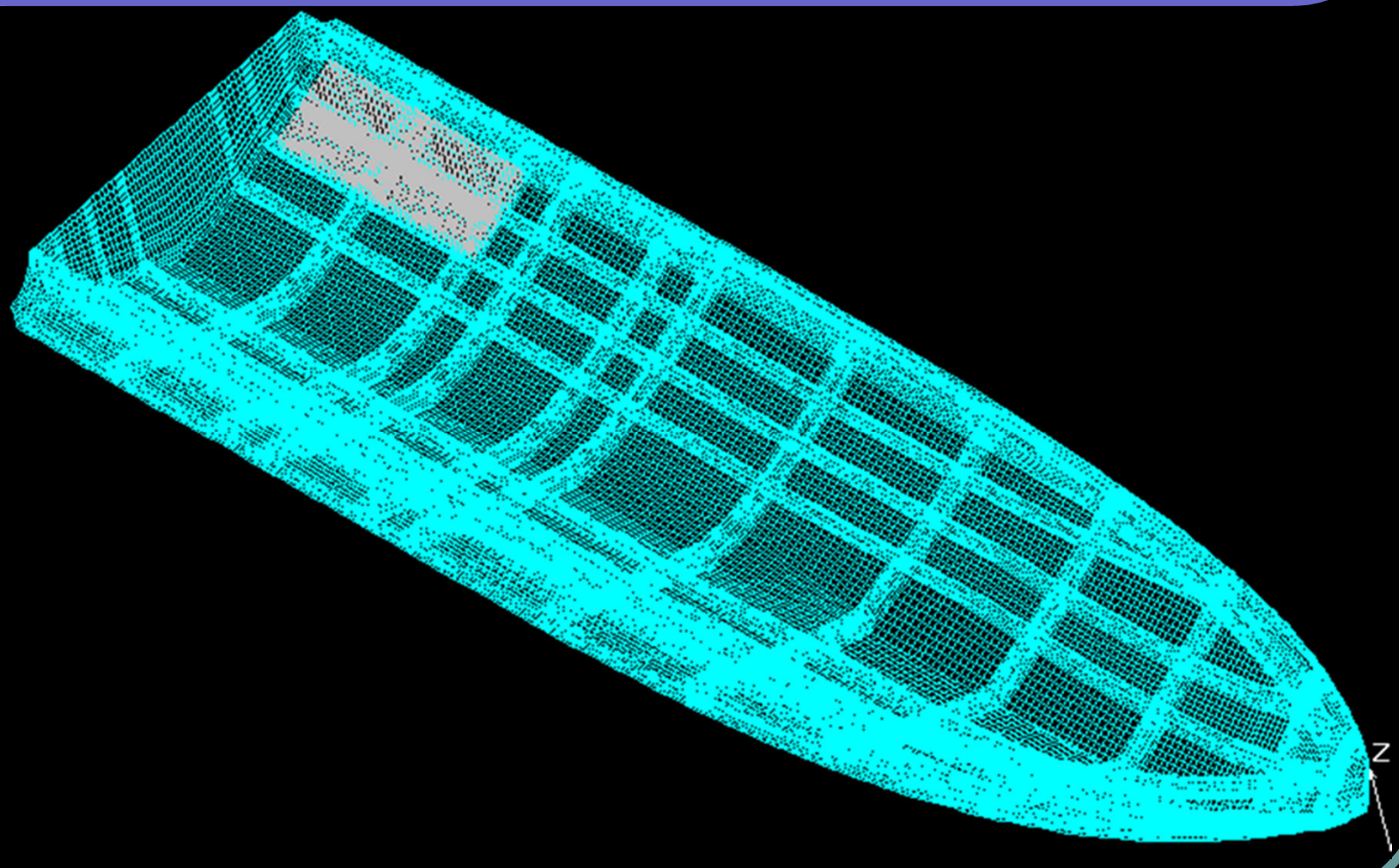


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LC1-FG- AI- Summary

- Hull range of deflection 1.36 in.
- Maximum Hull strain 0.0015 in/in
- Maximum Hull stress 5,500
- Maximum framing strain 0.004
- Maximum framing stress 12,000 psi

LC2-FG- AO-10 psi Pressure Load



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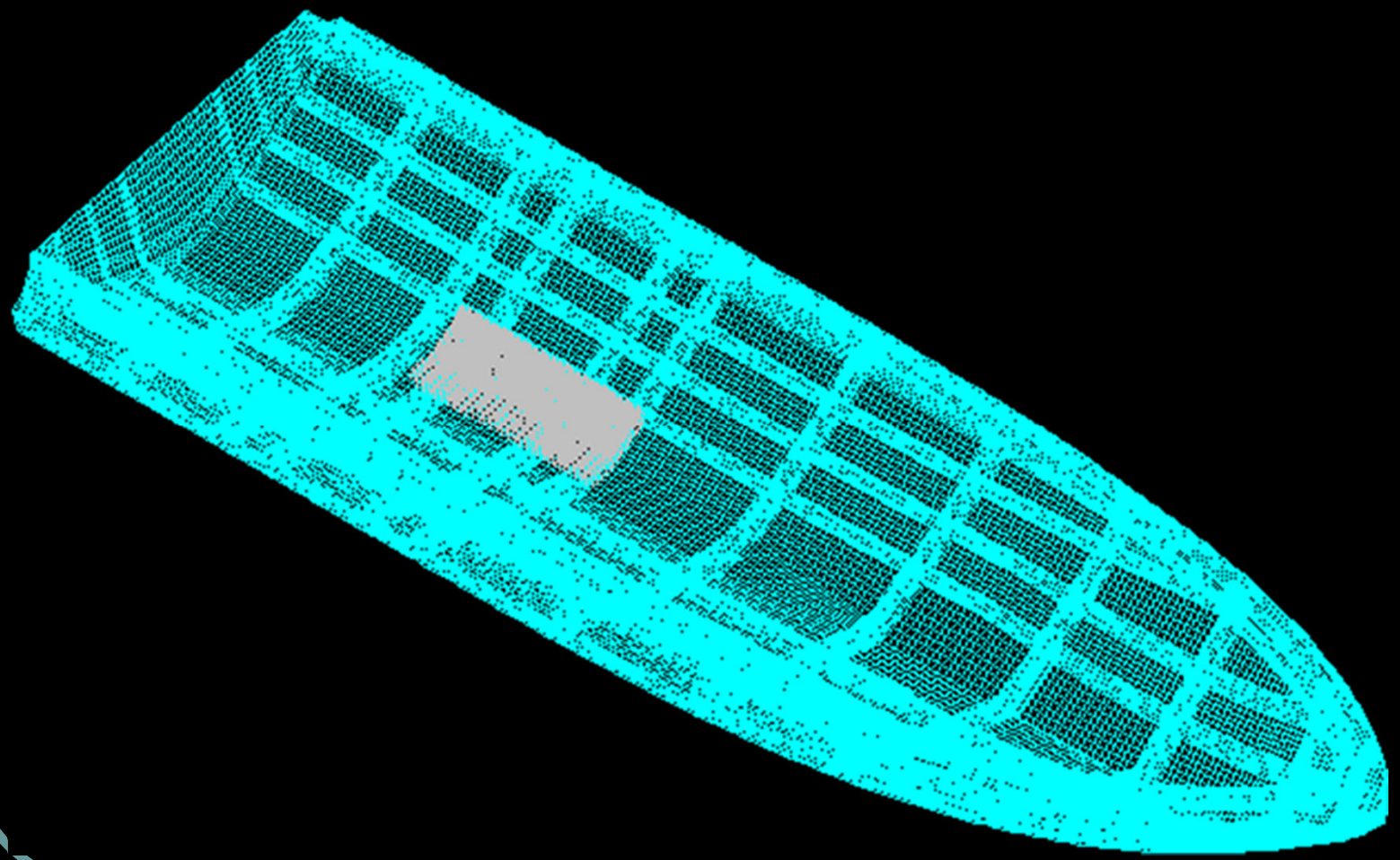
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LC2-FG AO- Summary

- Hull range of deflection 1.45 in.
- Maximum Hull strain 0.0018 in/in
- Maximum Hull stress 8,500
- Maximum framing strain 0.0036
- Maximum framing stress 16,000 psi

LC3-FG AMI-10 psi Pressure Load

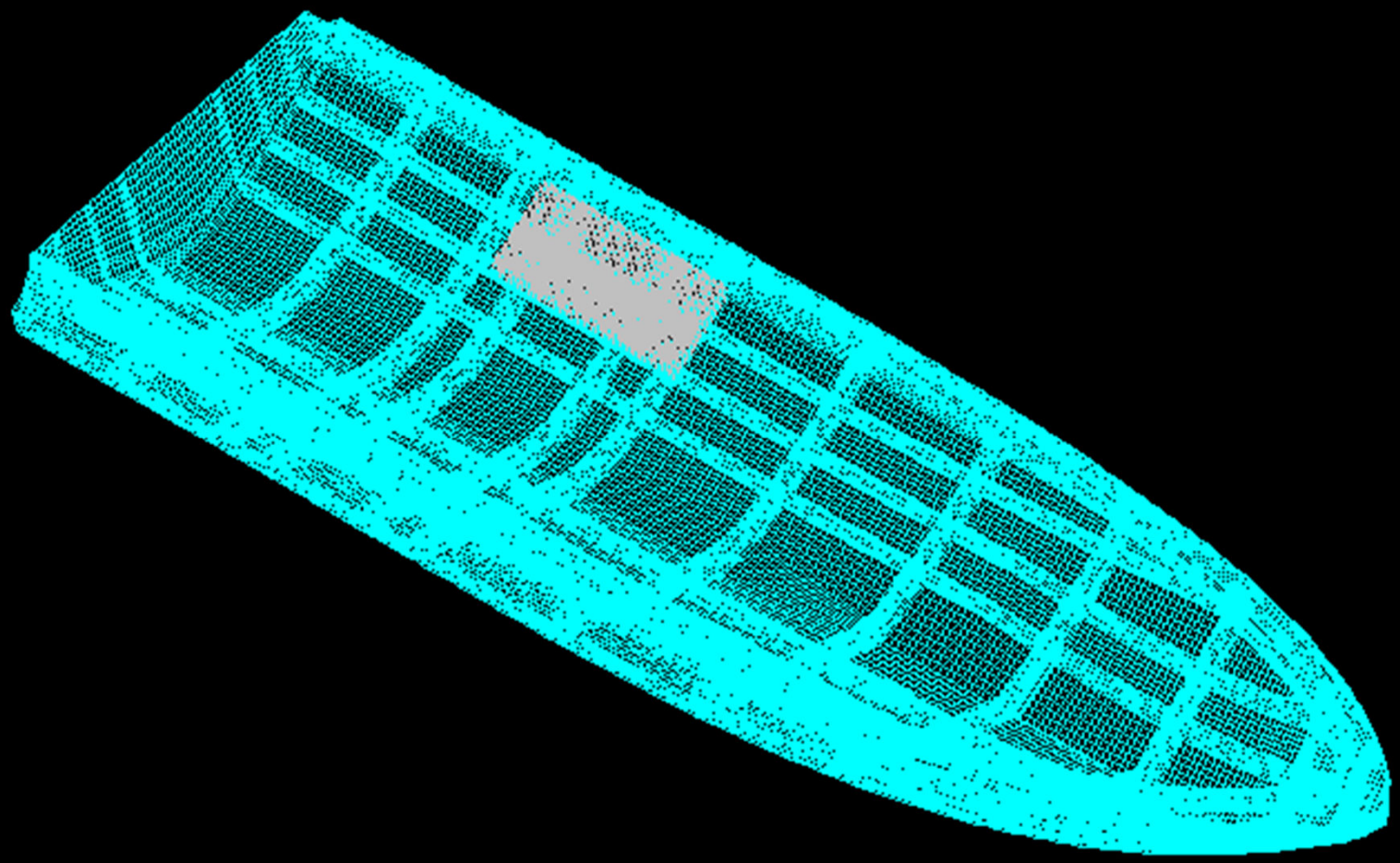


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LC3FG-AMI- Summary

- Hull range of deflection 0.17 in.
- Maximum Hull strain 0.0012 in/in
- Maximum Hull stress 5,500
- Maximum framing strain 0.002
- Maximum framing stress 9,000 psi

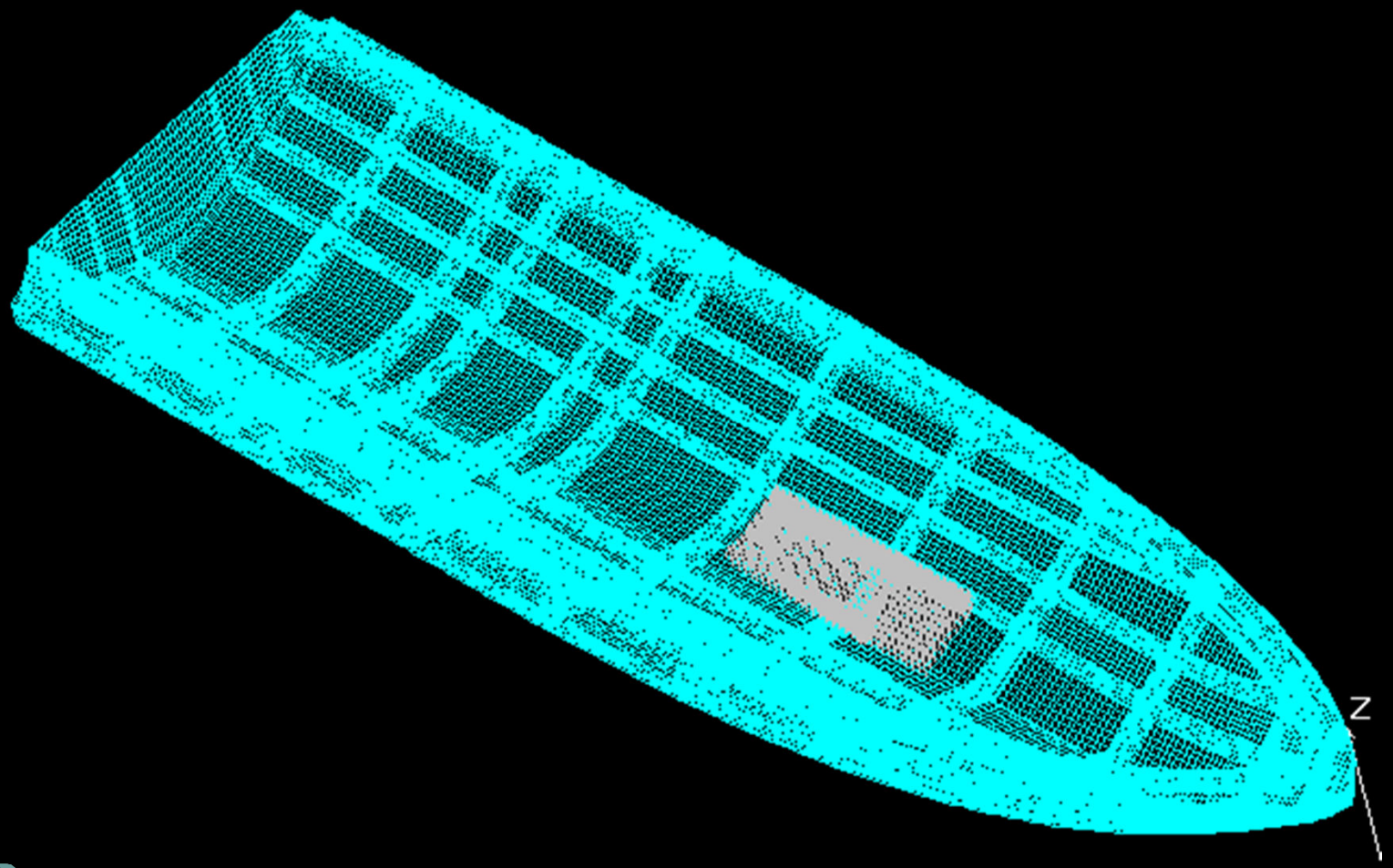
LC4FG- AMO-10 psi Pressure Load



LC4-FG- AMO- Summary

- Hull range of deflection 0.25 in.
- Maximum Hull strain 0.0012 in/in
- Maximum Hull stress 5,500
- Maximum framing strain 0.003
- Maximum framing stress 12,000 psi

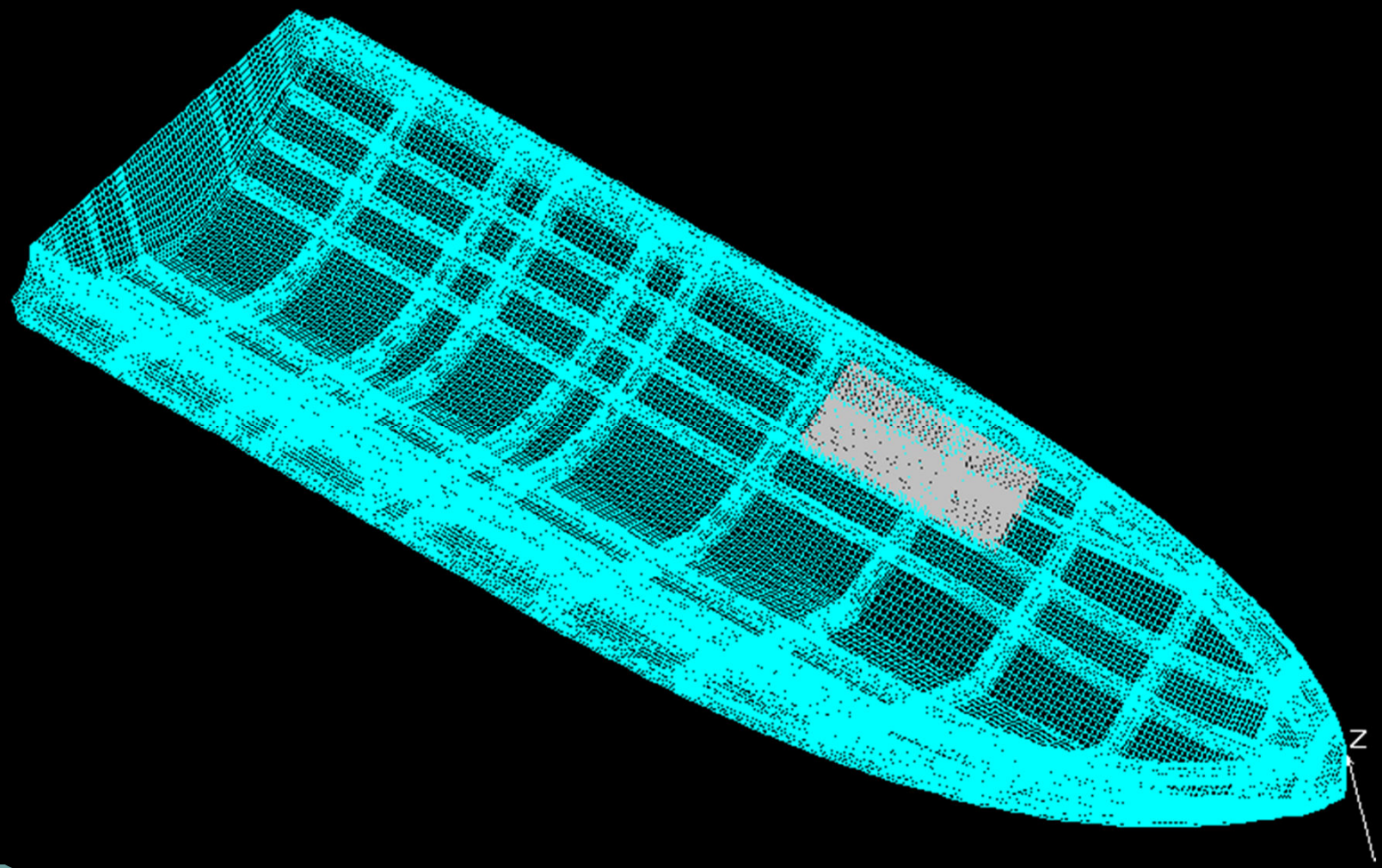
LC5-FG FMI-10 psi Pressure Load



LC5-FG FMI- Summary

- Hull range of deflection 4.66 in.
- Maximum Hull strain 0.0027 in/in
- Maximum Hull stress 7,500 psi
- Maximum framing strain 0.0033
- Maximum framing stress 12,000 psi

LC6-FG FMO-10 psi Pressure Load

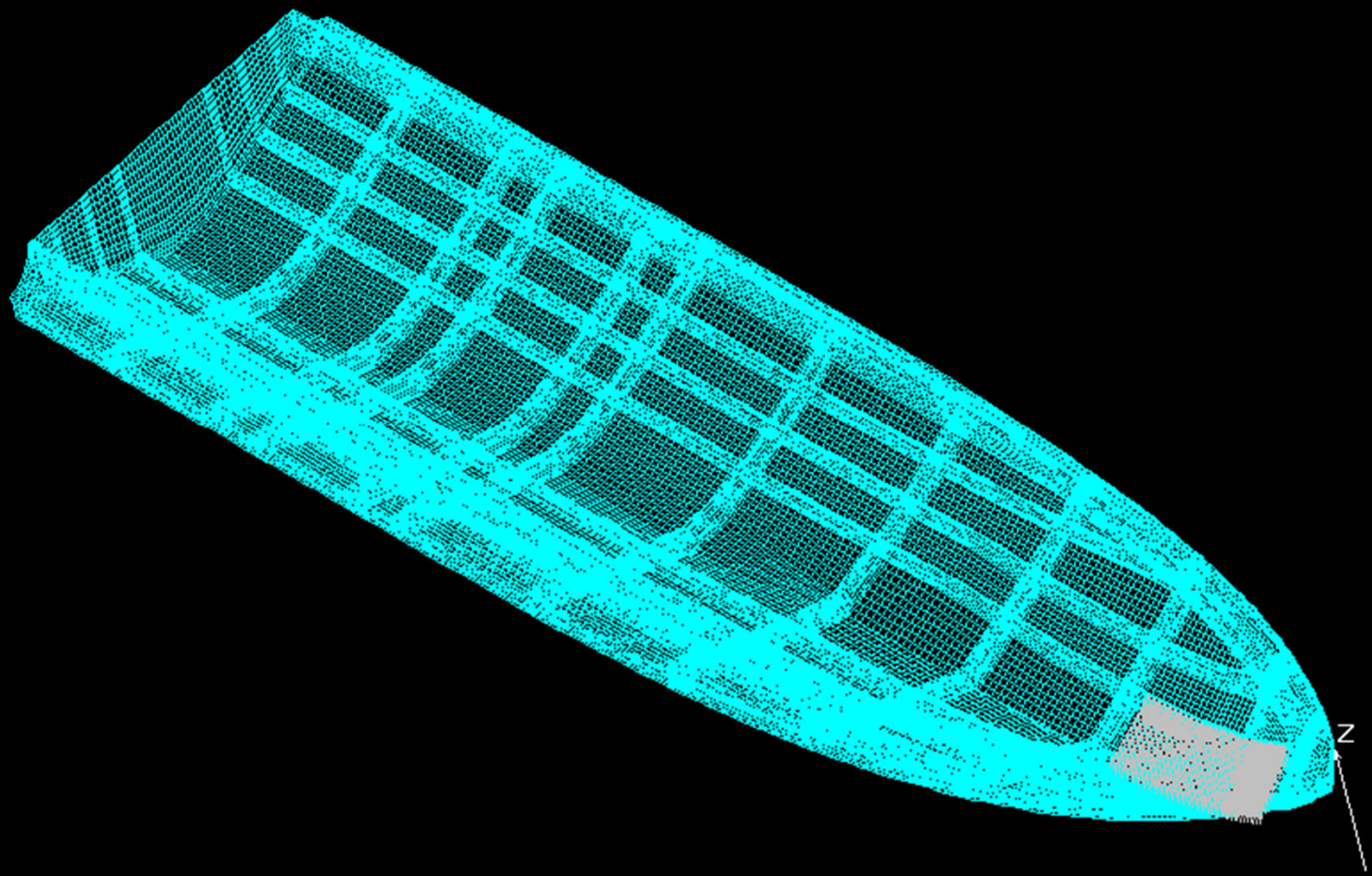


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LC6-FG FMO- Summary

- Hull range of deflection to 4.31 in.
- Maximum Hull strain 0.0033 in/in
- Maximum Hull stress 12,000
- Maximum framing strain 0.0048
- Maximum framing stress 20,000 psi

LC7-FG FI-10 psi Pressure Load



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LC7-FG FI- Summary

- Hull range of deflection 11.51 in.
- Maximum Hull strain 0.0024 in/in
- Maximum Hull stress 8,000
- Maximum framing strain 0.0033
- Maximum framing stress 12,000 psi

LC(1-7)- FG-SAS Summary

Range of maximum values in SAS cases

- Hull range of deflection -0.7 to 11.5 in.
- Maximum Hull strain 0.0033 in/in
- Maximum Hull stress 12,000 psi
- Maximum Frame strain 0.0036 in/in
- Max framing stress to 16,000 psi

11M- FEA Analysis: Boat Lifting Points (B.L.P.)



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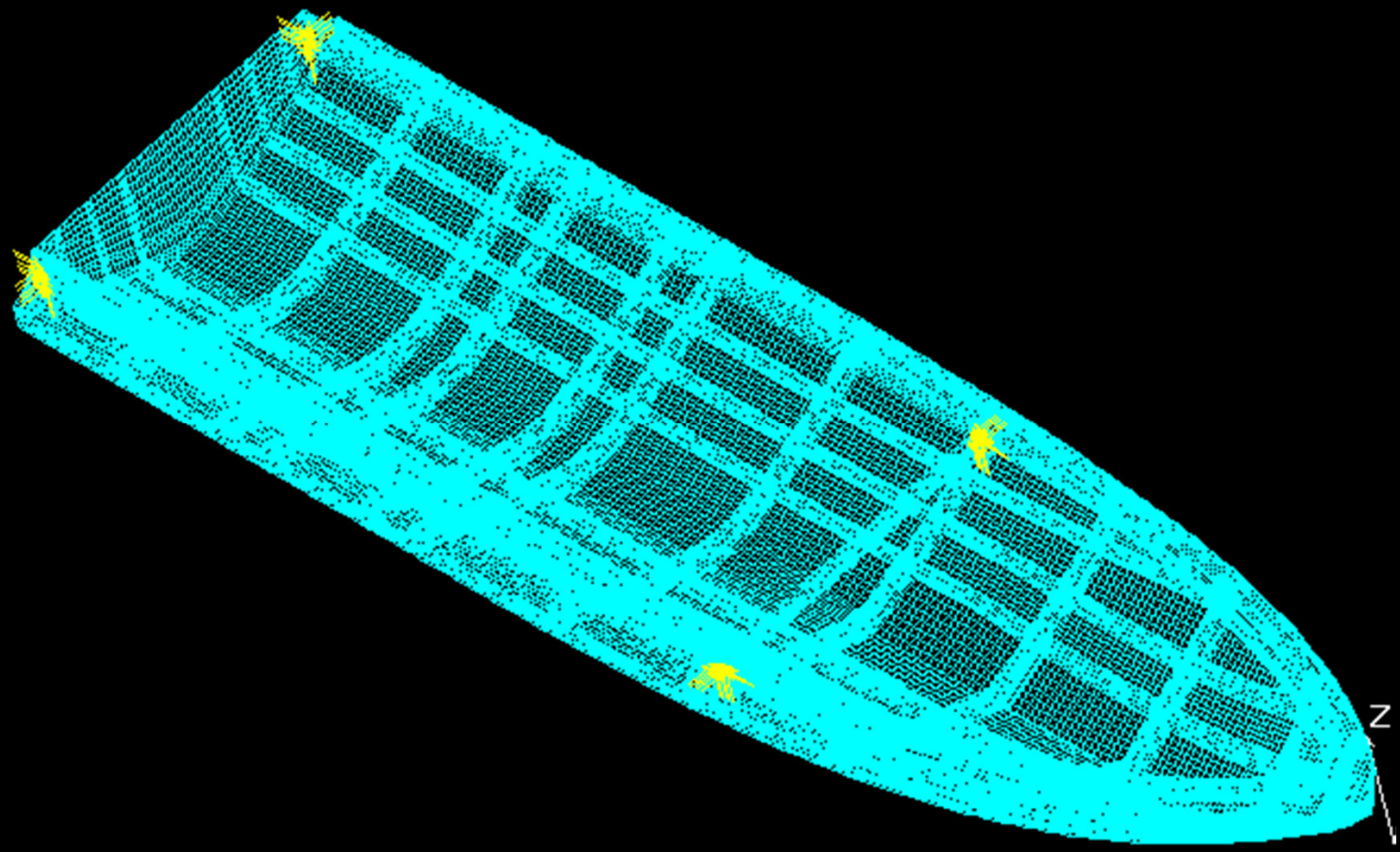
LC8- BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
- 55,490 lbs at engine mounts (from constraints)
- -50,110 lbs distributed load (-1 lb at each of 50,110 nodes)
- Total weight 105,600 lbs (6 x 17,600 lbs

LC8- BLP- Load Data

- Vertical loads
  - 26,400 lbs at each point
  - 105,600 lbs total (6 x 17,600 lbs)
- Transverse loads
  - -1056 lbs stbd side lift points
  - 1056 lbs port side lift points
- Longitudinal loads
  - 13,200 lbs at aft points
  - -13,200 lbs at fwd points

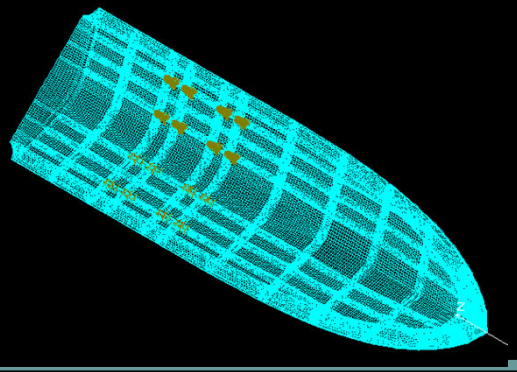
LC8-AL- BLP- Force Vector at Lift Points



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LC8- BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints F_r < 1 lb
- Thus constraints do not affect results



LC8-AL- BLP- Lift Analysis Summary

- Hull range of deflection -3.0 to 2.7 in.
- Maximum strain 0.02 in/in
- Maximum long stress 48,000 psi
- Maximum Transverse stress 70,000 psi
- Maximum 45 axis stress 80,000

11M- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)

31

LC9/LC10-Gun Mount Framing Notes

- This is a stiffness design, thus stresses are low
- Four transverse frames, TR2030X, are placed on 3.5 in centers
- Skin laminate is 4 layers of E LTM 3610 (entire foredeck, including tube support areas)
- Frame laminate
  - 24 oz (+/-45) on PRISMA beam
  - 4 layers 4” wide E LM 1810 warp uni on frame caps
  - E BXM 2408 (+/-45) cover fabric (overlapping adjacent tabs)

LC9- GML- Long. Loading

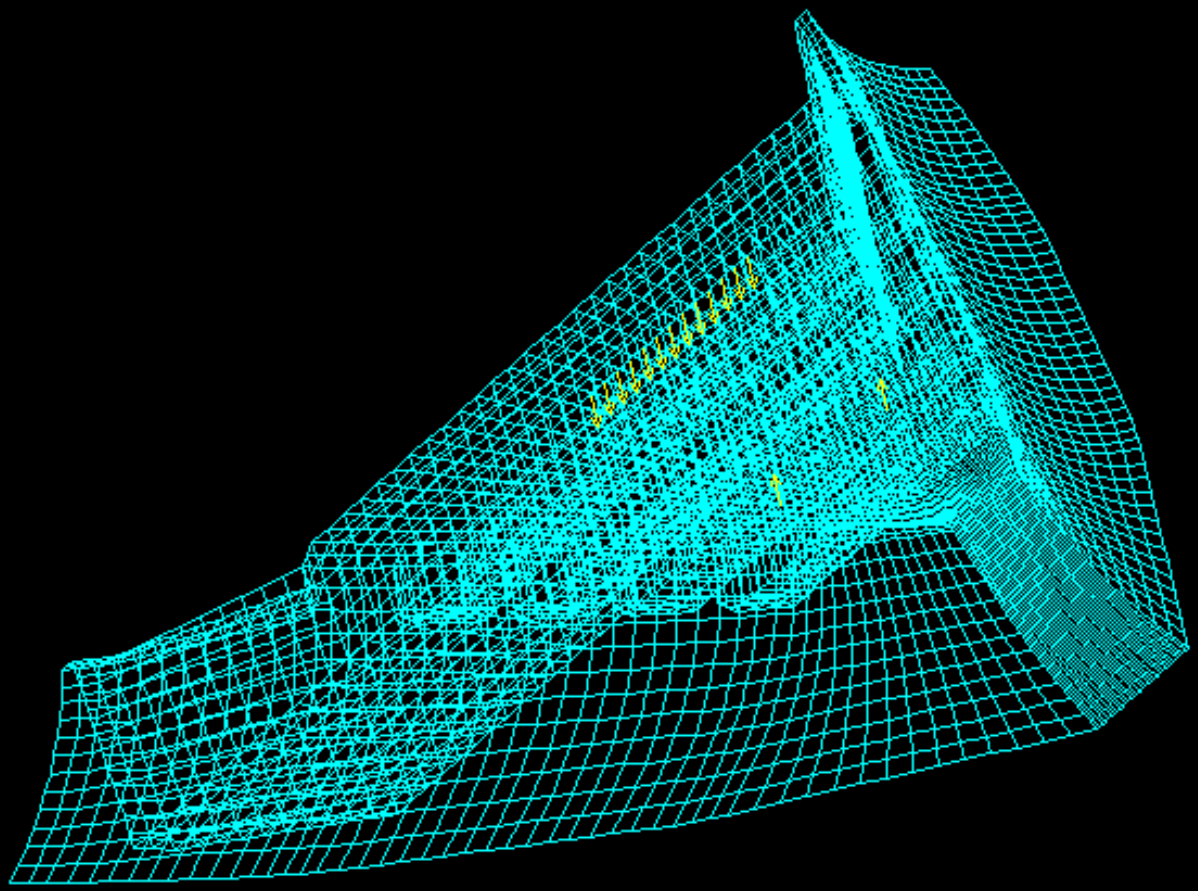
Forward

- Two bolts
- Tensile loading 2250 lbs each bolt

Aft

- Loading at 13 nodes along aft edge of mounting plate
- Compressive loading 347 lbs each point

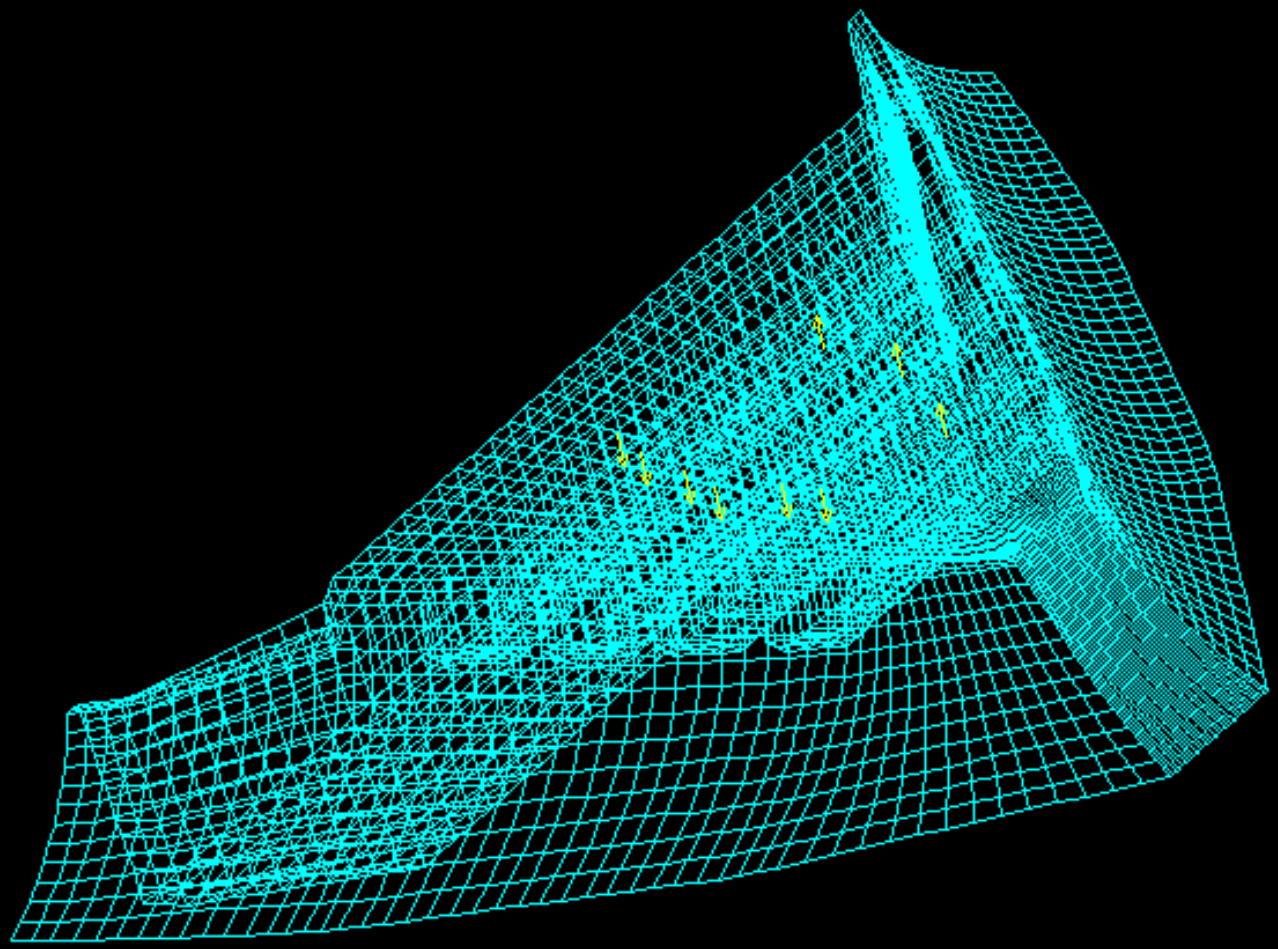
LC9- GML- Long. Loading



LC9-11M- G.M.L- Summary

- Range of deflection -.14 to .11 in.
- Maximum strain 0.004 in./in.
- Maximum longitudinal stress 12,000 psi
- Maximum transverse stress 12,000 psi

LC10- GMT- Trans. Loading



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LC10- G.M.T- Summary

- Range of deflection -.25 to .18 in.
- Maximum strain 0.004 in./in.
- Maximum longitudinal stress 6,000 psi
- Maximum transverse stress 8,000 psi

LC9 and LC10 Gun Mount Summary

- This is a stiffness design, thus stresses are low
- The structure is adequate
- FOS for strength in excess of 10

11M- FEA- Fiberglass Design

- Loads
  - Small Area Slam (SAS)
  - Trailer Load Analysis
- Laminate Revisions
  - Hull- Fiberglass vs. Advanced Laminate
  - Framing- Unchanged
  - Deck- Unchanged

11M- FEA Analysis:
Trailer Load Analysis (TLA)
FiberGlass Design

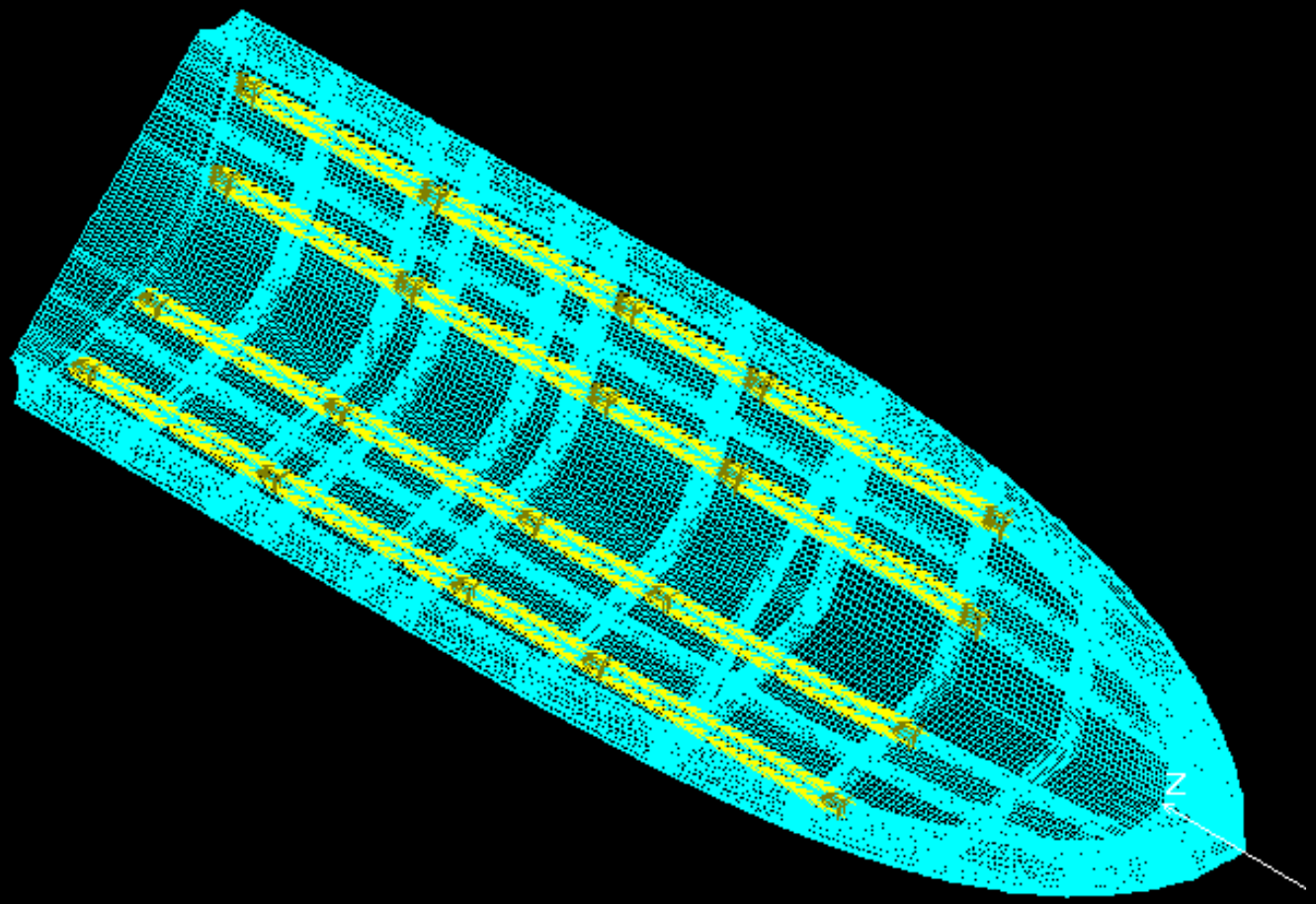


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LC8-FG- Trailer Loads Applied

- 3G vertical acceleration (51,000 lbs)
- Weight is uniformly distributed over boat (-1.06 lbs on each node = -51,000 lbs
- Boat is supported by 4 bunks, located under inner and outer stringers on each side
- Bunk support modeled as vertical force applied along bottom side of stringer frames (50 lbs on each of 1008 nodes for 50,400 lbs)
- Bunk supports modeled as vertical constraints (600 lbs total reaction)

LC8-FG - Trailer Loads- Bunk and Loading Constraints



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LC8-FG TLA- Summary

- Hull range of deflection -2.3 to .1 in.
- Maximum Hull strain 0.004 in/in
- Maximum framing stress 15,000 psi

LC8-FG- TLA Summary

- Structural Analysis for 3 G “hit” while traveling on trailer
- Stresses and strains are low except at the forward end of the support bunk, where a minimum safety factor of 8 (i.e. a 24 G acceleration is required to break the boat structure)

Weight Evaluation Advanced and FG

Component	AL – Weight (lb)	FG – Weight (lb)
Hull	930-960	1070-1100
Deck	470-490	470-490
Total Weight Hull and Deck	**1400-1450 55% to 57% Savings from Baseline**	**1540 - 1590 50 to 53% Savings from Baseline**

Weight Evaluation FG Fiberglass Laminate

Component	Weight (lb)
Hull	1070-1100
Deck	470-490

Total Weight Hull and Deck Fiberglass Hull Laminate	**1540 - 1590 50 to 53% Savings from Baseline**

Preliminary Design Summary - Fiberglass

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 11M- Exceeds Metrics, On Target

11M Conclusions

- Both Advanced and Fiberglass designs are adequate
- Both Designs Exceed Weight Reduction Goal
- Fiberglass Design chosen for Rapid Implementation- Lower Risk
- Advanced Design recommended if Navy Desires to advance new materials- Higher Risk

11M- Extended Drawings and FEA Analysis Slides



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11M- Drawings Package Fiberglass Design



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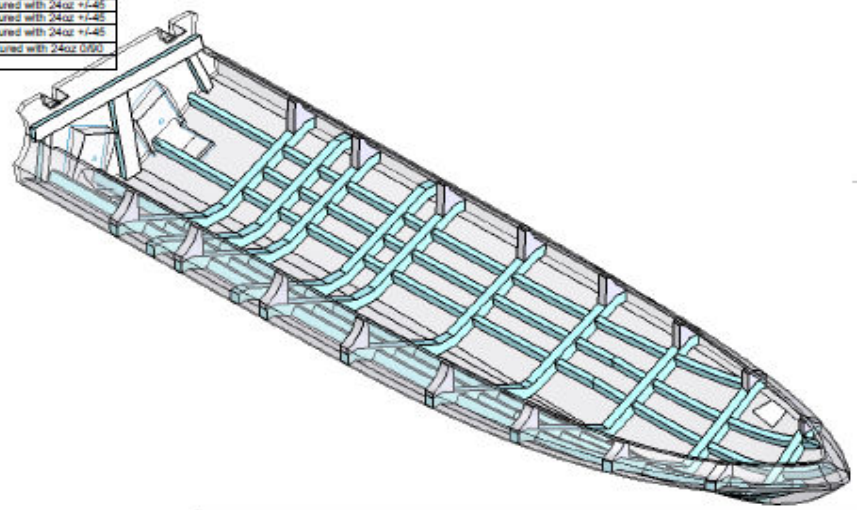
11M- Hull Drawings – Fiberglass Design

BOM

ITEM NO.	QTY	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel Coat	Ashland Chemical Company (GA)	AG-33LS-2455 US Grey	
2	A/R	Resin	Interplastic	CORVE 8106	
3	A/R	Resin	Interplastic	CORVE 8123	
4	A/R	2oz Chopped Strand Mat			
5	A/R	E LTM 3610 0/90 fabric	Vectorply	E LTM 3610	0/90 fabric
6		not used			
7	A/R	E-BXM 2408 +/-45 fabric	Vectorply	E-BXM 2408	+/-45 fabric
8	A/R	E-BXM 1208 +/-45 fabric	Vectorply	E-BXM 1208	+/-45 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	A/R	E-BXM1715 +/-45 fabric - 3" wide	Vectorply	E-BXM1715	+/-45 fabric
11		not used			
12	75 LF	TR4040X	Compsys	TR4030X	manufactured with 24oz +/-45
13	1	Starboard Mid Stringer	Compsys	ZDC11M-SFMS	manufactured with 24oz +/-45
14	1	Starboard Inboard Stringer	Compsys	ZDC11M-SFIS	manufactured with 24oz +/-45
15	1	Port Mid Stringer	Compsys	ZDC11M-PFMS	manufactured with 24oz +/-45
16	1	Port Inboard Stringer	Compsys	ZDC11M-PFIS	manufactured with 24oz +/-45
17		not used			
18	2 LF	TR3726X	Compsys	TR3726X	manufactured with 24oz +/-45
19	5 LF	TR6026X	Compsys	TR6026X	manufactured with 24oz +/-45
20	15 LF	TR8026X	Compsys	TR8026X	manufactured with 24oz +/-45
21	1	Bulkhead A	Compsys	ZDC11M-BH10	manufactured with 24oz +/-45
22	1	Bulkhead B	Compsys	ZDC11M-BH09	manufactured with 24oz +/-45
23	1	Bulkhead C	Compsys	ZDC11M-BH08	manufactured with 24oz +/-45
24	1	Bulkhead D	Compsys	ZDC11M-BH07	manufactured with 24oz +/-45
25	1	Bulkhead E	Compsys	ZDC11M-BH06	manufactured with 24oz +/-45
26	1	Bulkhead F	Compsys	ZDC11M-BH05	manufactured with 24oz +/-45
27	1	Bulkhead G	Compsys	ZDC11M-BH04	manufactured with 24oz +/-45
28	1	Bulkhead H	Compsys	ZDC11M-BH03	manufactured with 24oz +/-45
29	1	Bulkhead I	Compsys	ZDC11M-BH02	manufactured with 24oz +/-45
30	1	Bulkhead J	Compsys	ZDC11M-BH01	manufactured with 24oz +/-45
31	100 LF	FS2010	Compsys	FS2010	manufactured with 24oz 0/90
32	A/R	1/2" PVC SCH 80		1/2" PVC	

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
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2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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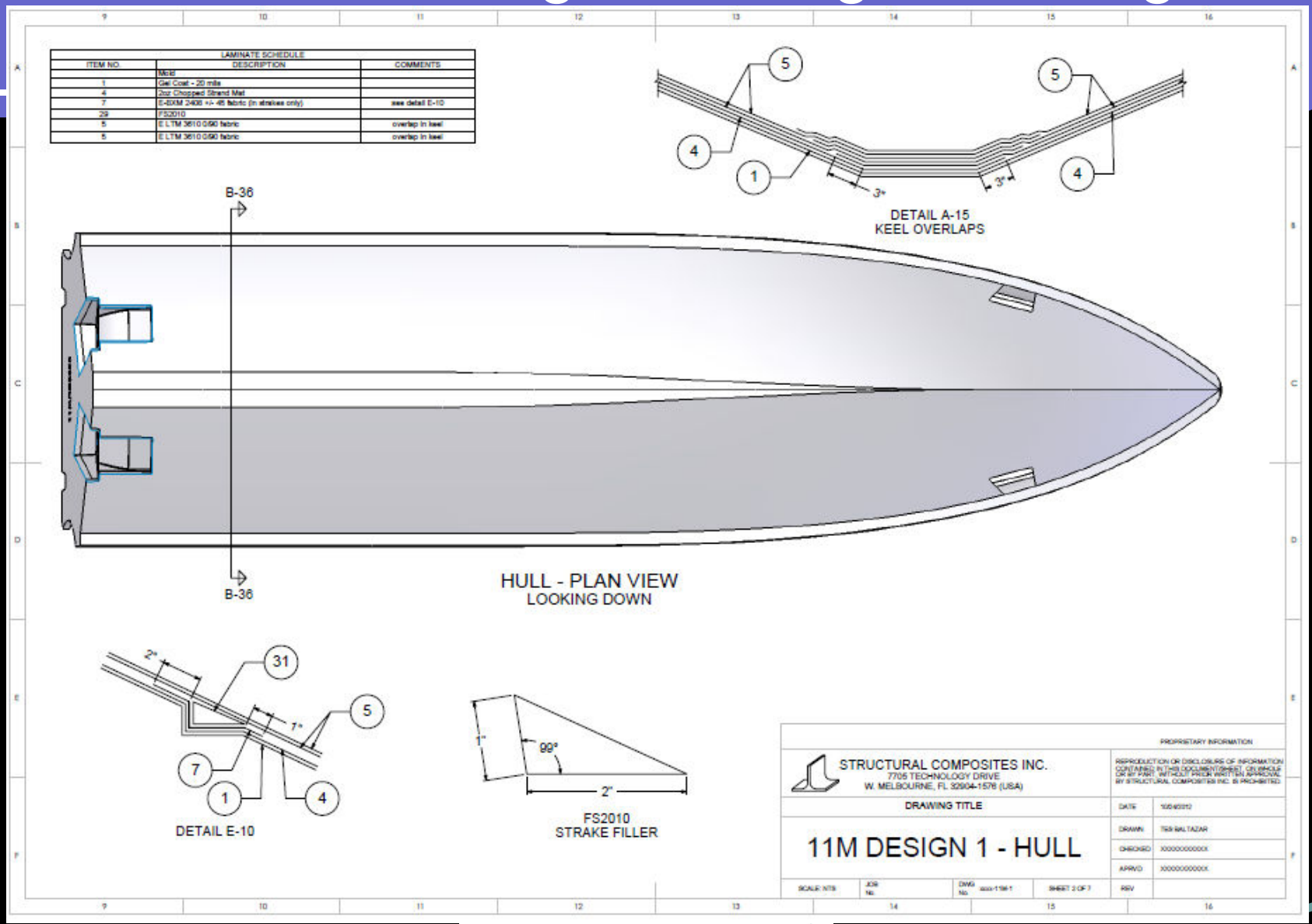
11M DESIGN 1 - HULL

DATE	10/24/2012
DRAWN	TSS BALTAZAR
CHECKED	XXXXXXXXXXX
APPVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. xxxx-11M-1 | SHEET 1 OF 7

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11M- Hull Drawings – Fiberglass Design

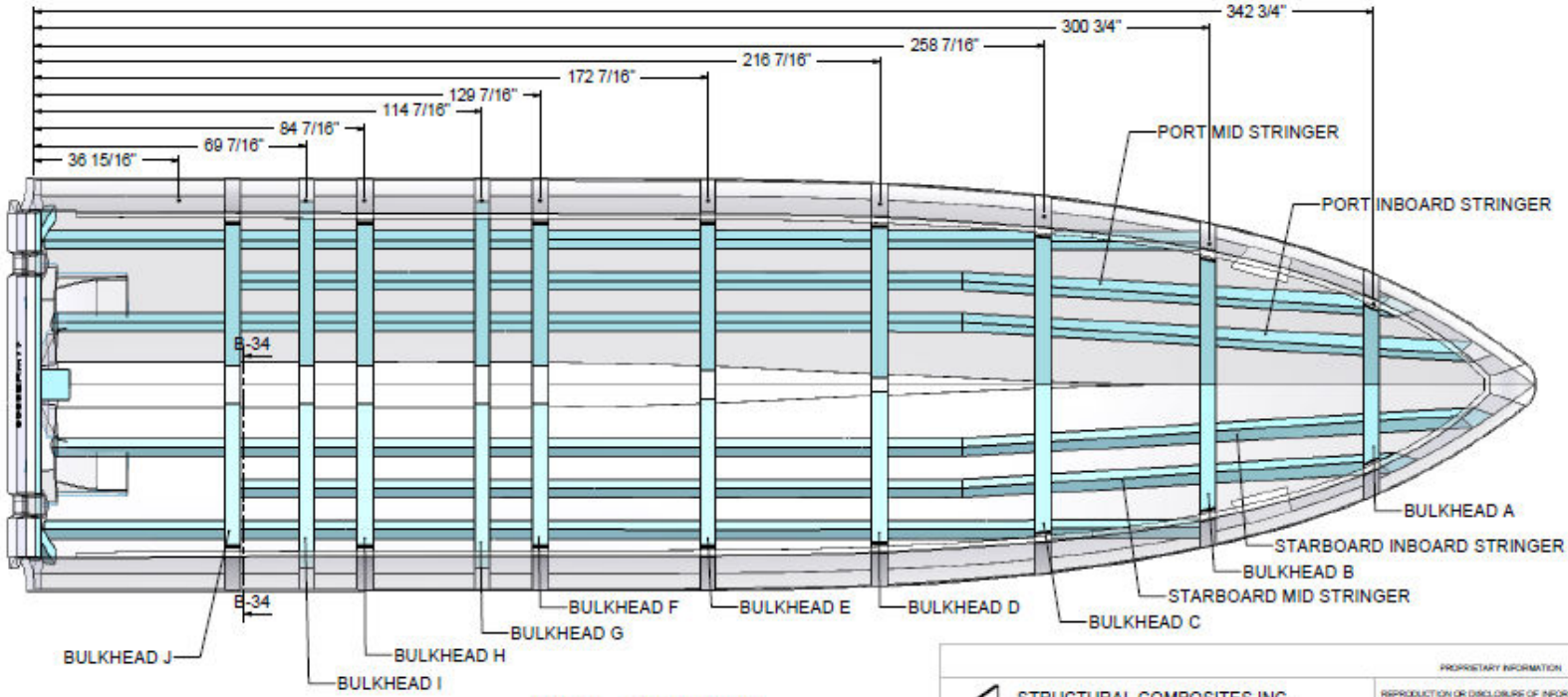


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11M- Hull Drawings – Fiberglass Design

LAMINATE SCHEDULE

ITEM NO.	DESCRIPTION	COMMENTS
12	TR40400X	manufactured with 24oz +/-45
13	Starboard Mid Stringer	manufactured with 24oz +/-45
14	Starboard Inboard Stringer	manufactured with 24oz +/-45
15	Port Mid Stringer	manufactured with 24oz +/-45
16	Port Inboard Stringer	manufactured with 24oz +/-45
21	Bulkhead A	manufactured with 24oz +/-45
22	Bulkhead B	manufactured with 24oz +/-45
23	Bulkhead C	manufactured with 24oz +/-45
24	Bulkhead D	manufactured with 24oz +/-45
25	Bulkhead E	manufactured with 24oz +/-45
26	Bulkhead F	manufactured with 24oz +/-45
27	Bulkhead G	manufactured with 24oz +/-45
28	Bulkhead H	manufactured with 24oz +/-45
29	Bulkhead I	manufactured with 24oz +/-45
30	Bulkhead J	manufactured with 24oz +/-45
8	E-LM 1810 0 fabric	
9	E-LM 1810 0 fabric	
9	E-LM 1810 0 fabric	
8	E-3XM 2308 +/-45 fabric	



HULL - PLAN VIEW
LOOKING DOWN

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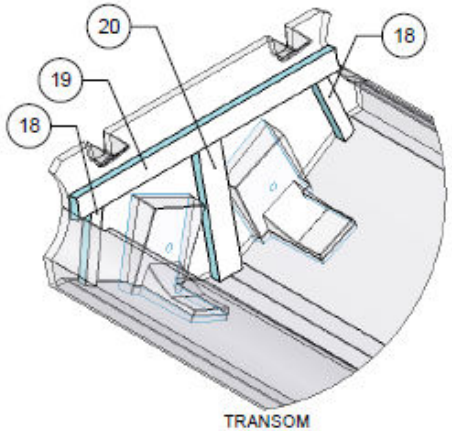
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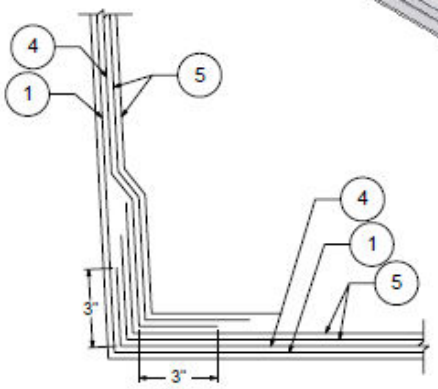
11M- Hull Drawings – Fiberglass Design

LAMINATE SCHEDULE

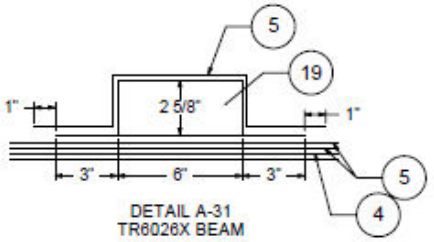
ITEM NO.	DESCRIPTION	COMMENTS
	Mold	
1	Gel Coat - 20 mils	
4	2oz Chopped Strand Mat	
5	E LTM 3610 0/90 fabric	
5	E LTM 3610 0/90 fabric	
18	TR3726X	
19	TR8026X	
20	TR8026X	
5	E-LTM 3610 0/90 fabric	cut at 45°
26	Starboard transom knee	
26	Port Transom Knee	



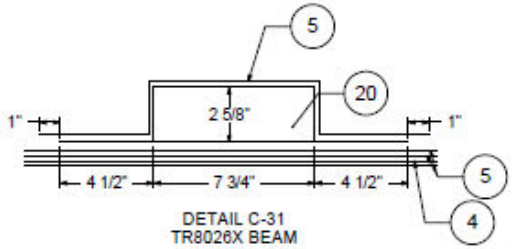
TRANSOM



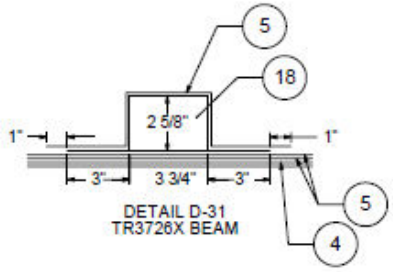
DETAIL E-26
HULL/TRANSOM LAMINATE DETAIL



DETAIL A-31
TR6026X BEAM



DETAIL C-31
TR8026X BEAM



DETAIL D-31
TR3726X BEAM

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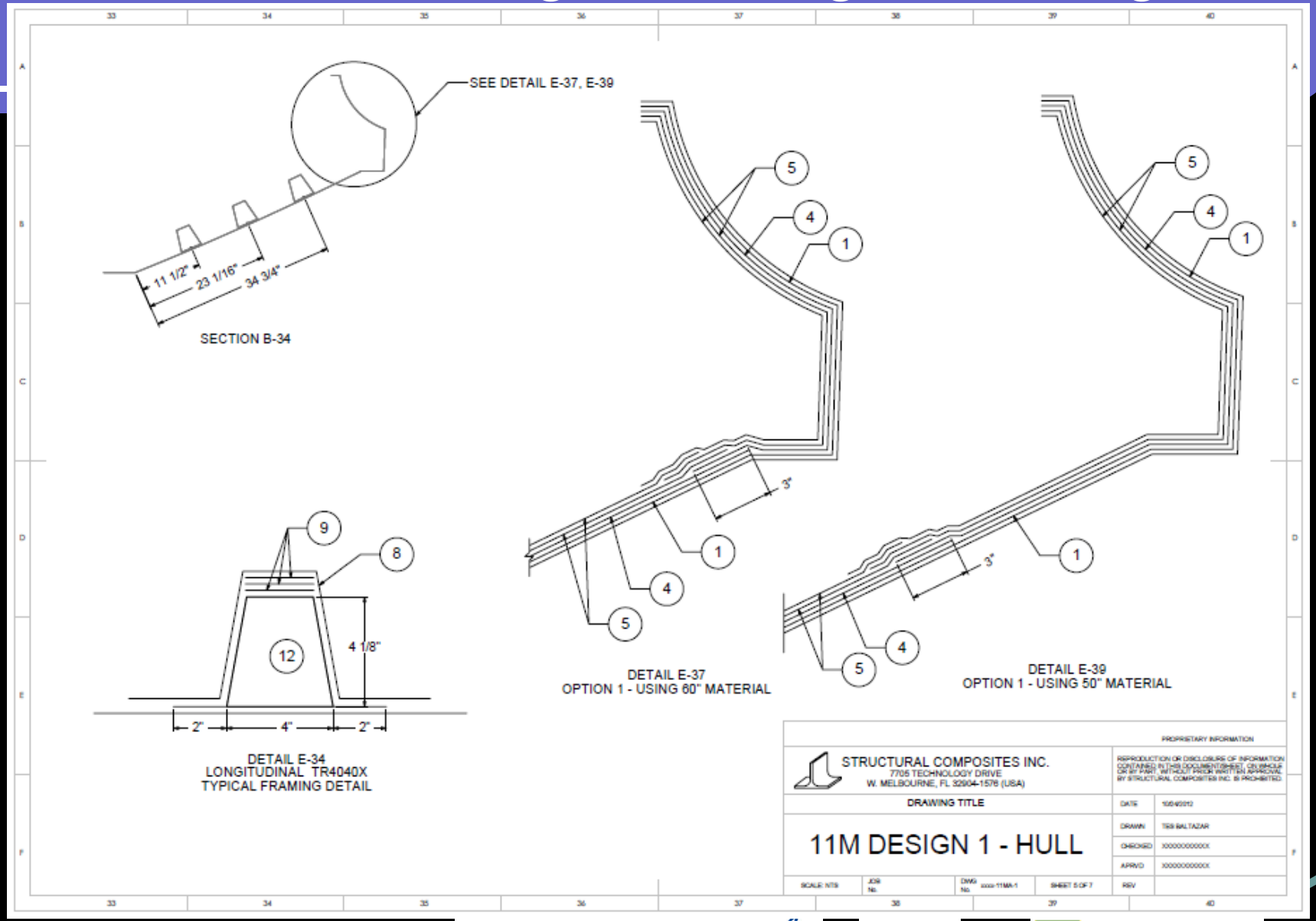
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APPVD	XXXXXXXXXX
REV	

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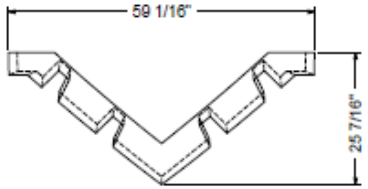
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11M- Hull Drawings – Fiberglass Design

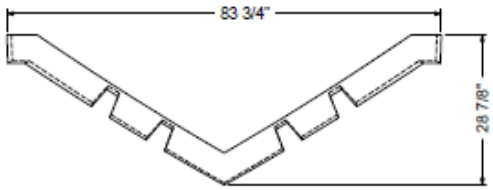


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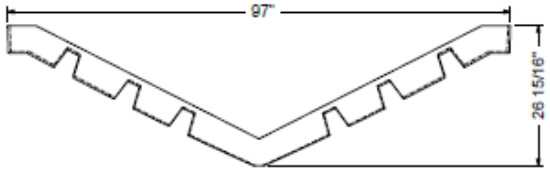
11M- Hull Drawings – Fiberglass Design



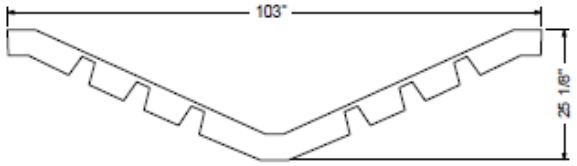
DETAIL B-42
BULKHEAD A



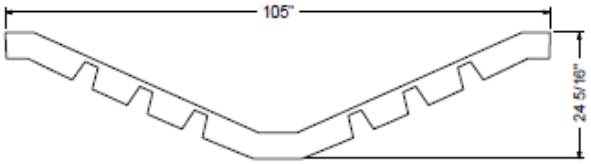
DETAIL D-42
BULKHEAD B



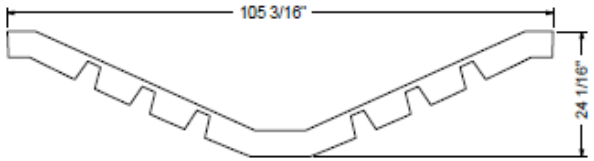
DETAIL E-42
BULKHEAD C



DETAIL B-46
BULKHEAD D



DETAIL C-46
BULKHEAD E



DETAIL E-46
BULKHEAD F,G,H,I,J

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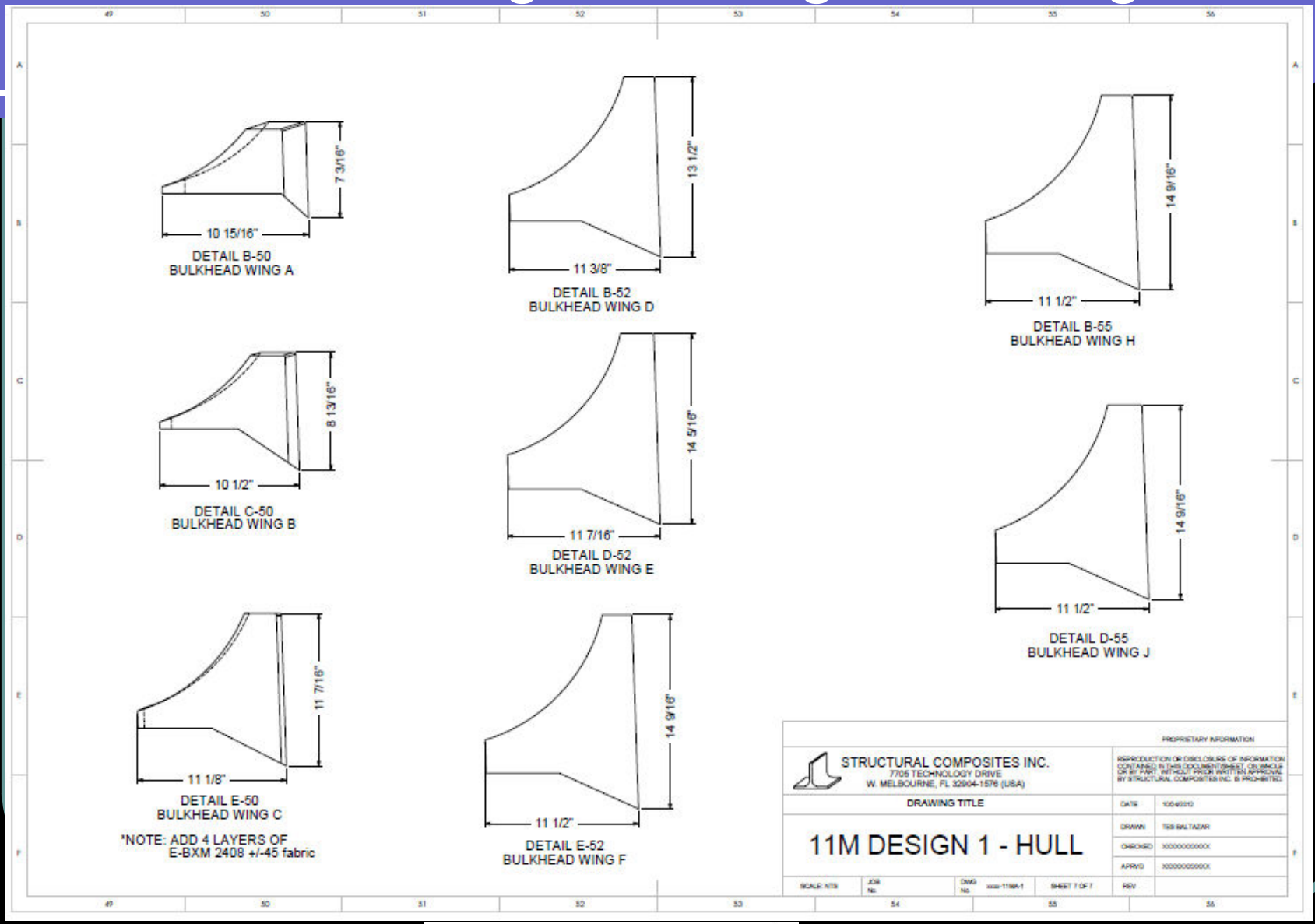
11M DESIGN 1 - HULL

DATE	10/24/2012
DRAWN	TSS BALTAZAR
CHECKED	XXXXXXXXXX
APRVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. xxxx-11MA-1 | SHEET 6 OF 7

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11M- Hull Drawings – Fiberglass Design



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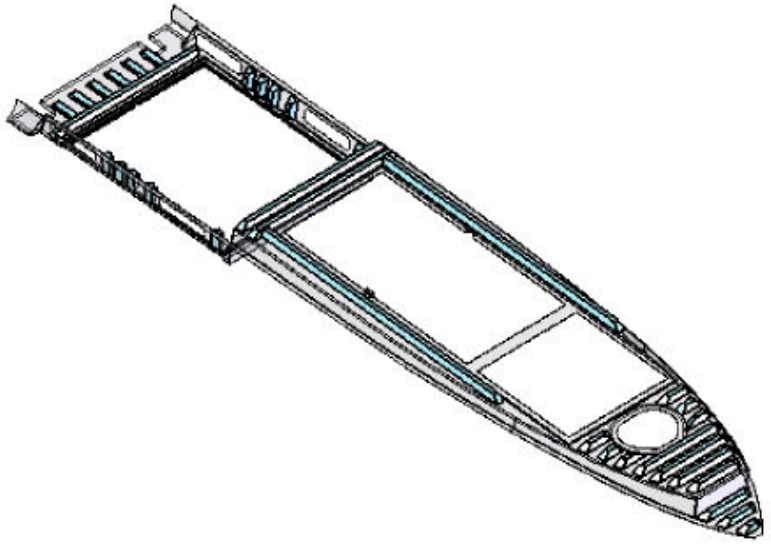
11M- Deck Drawings

BOM

ITEM NO.	QTY.	DESCRIPTION	MANUFACTURER	MODEL/PART #	COMMENTS
1	A/R	Gel coat	Ashland Chemical Company (GA)	AG-33LE-2435 UB Gray	
2	A/R	Resin	Interplastic	CORVE 8106	
3		not used			
4	A/R	2oz Chopped Strand Mat			
5		not used			
6	A/R	E-BXM1208 +/- fabric	Vectorply	E-BXM 1208	+/- fabric
7	A/R	2308BX	Vectorply	2308BX	
8	A/R	E-LTM 1808 0/90 fabric	Vectorply	E-LTM-1808	0/90 fabric
9	A/R	E-LM 1810 0 fabric - 3" wide	Vectorply	E-LM 1810	0 fabric
10	80 LF	TR4030	Compsys	TR4030	manufactured with 24oz 0/90
11	10 LF	TR4010	Compsys	TR4010	manufactured with 24oz 0/90
12		not used			
13		not used			
14		not used			
15		not used			

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED



GENERAL NOTES:
1) All materials to be "or equivalent" for acquisition purposes with the approval of the Customer.
2) See Builders Process Description XXXX for additional details on the manufacturing process.
3) Workmanship to be in accordance with Good Commercial Practice.
4) Follow manufacturer's recommendation for promotion and catalyst levels to achieve the necessary working time to complete fabrication.

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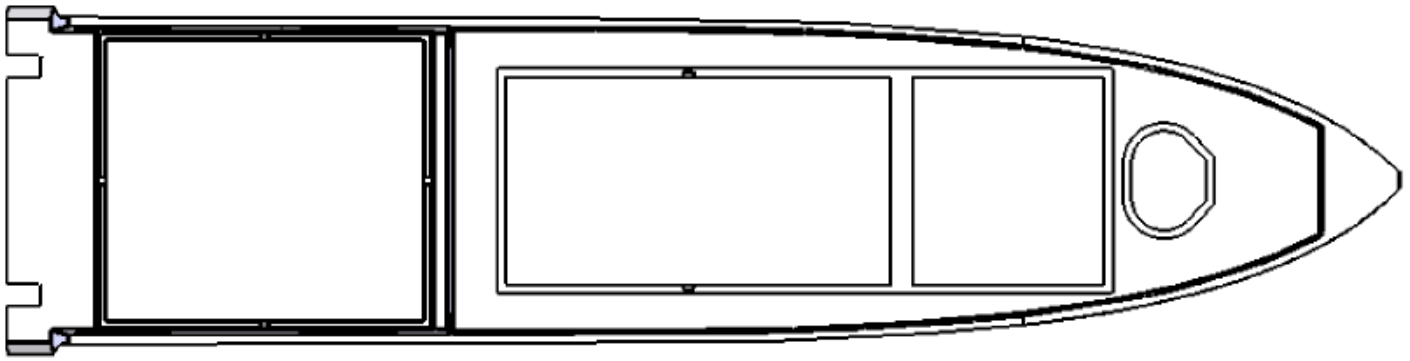
11M - DECK

DATE	11/30/2012
DRAWN	TES BALTAZAR
CHECKED	XXXXXXXXXXX
APRVD	XXXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-1 | SHEET 1 OF 3

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11M- Deck Drawings



DECK - PLAN VIEW
LOOKING UP

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DRAWING TITLE

11M - DECK

DATE	11/29/2012
DRAWN	TEB BALTAZAR
CHECKED	XXXXXXXXXX
APPVD	XXXXXXXXXX
REV	

SCALE: NTS | JOB No. | DWG No. XXXX-11M-2 | SHEET 2 OF 3

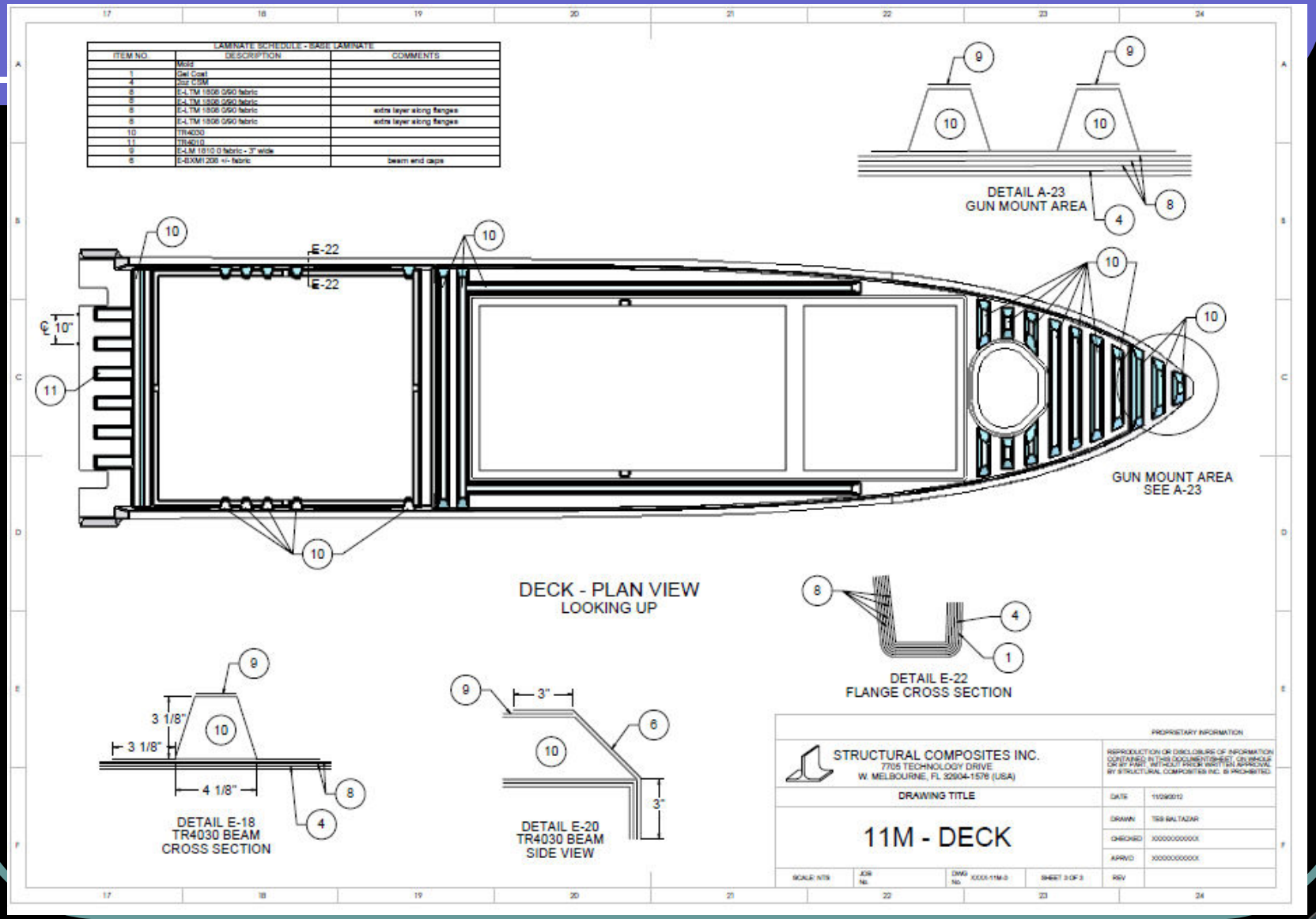
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11M- Deck Drawings



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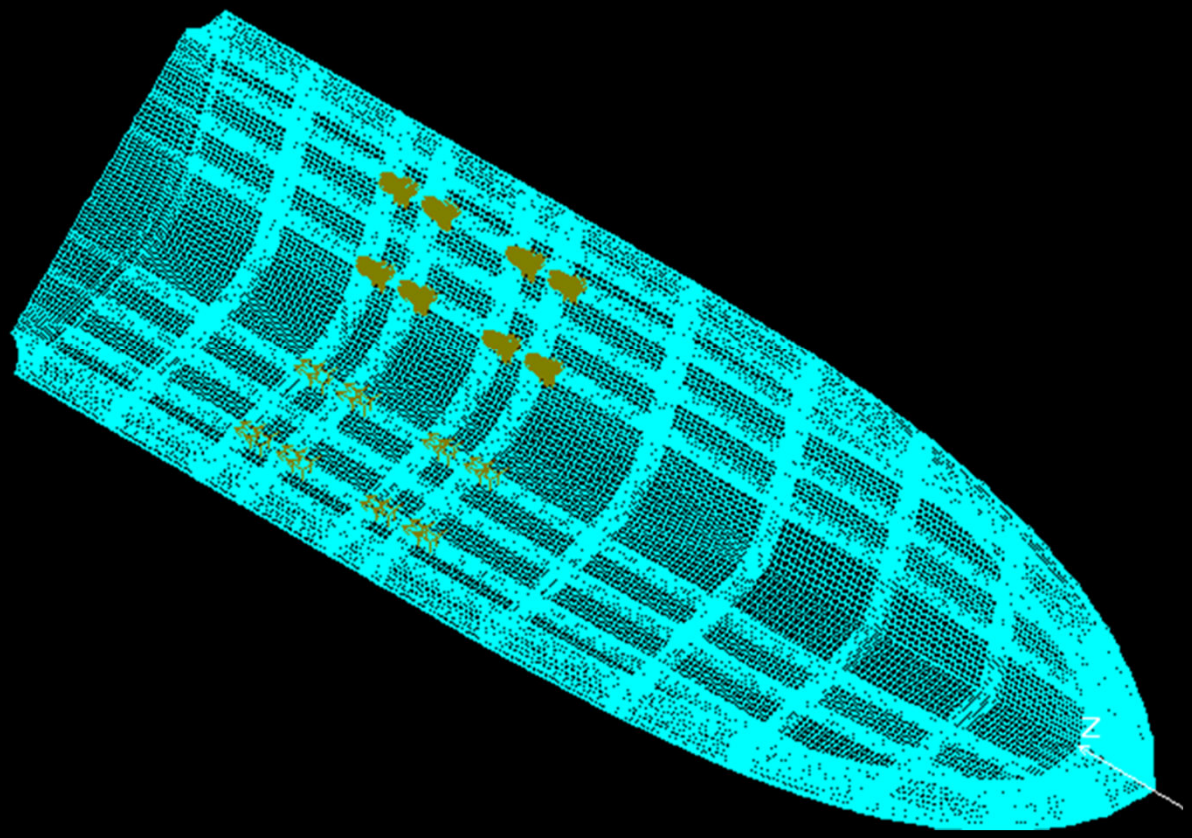
11M- FEA Analysis- Fiberglass Design



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11M- FEA Fiberglass- Constraints

Constraints



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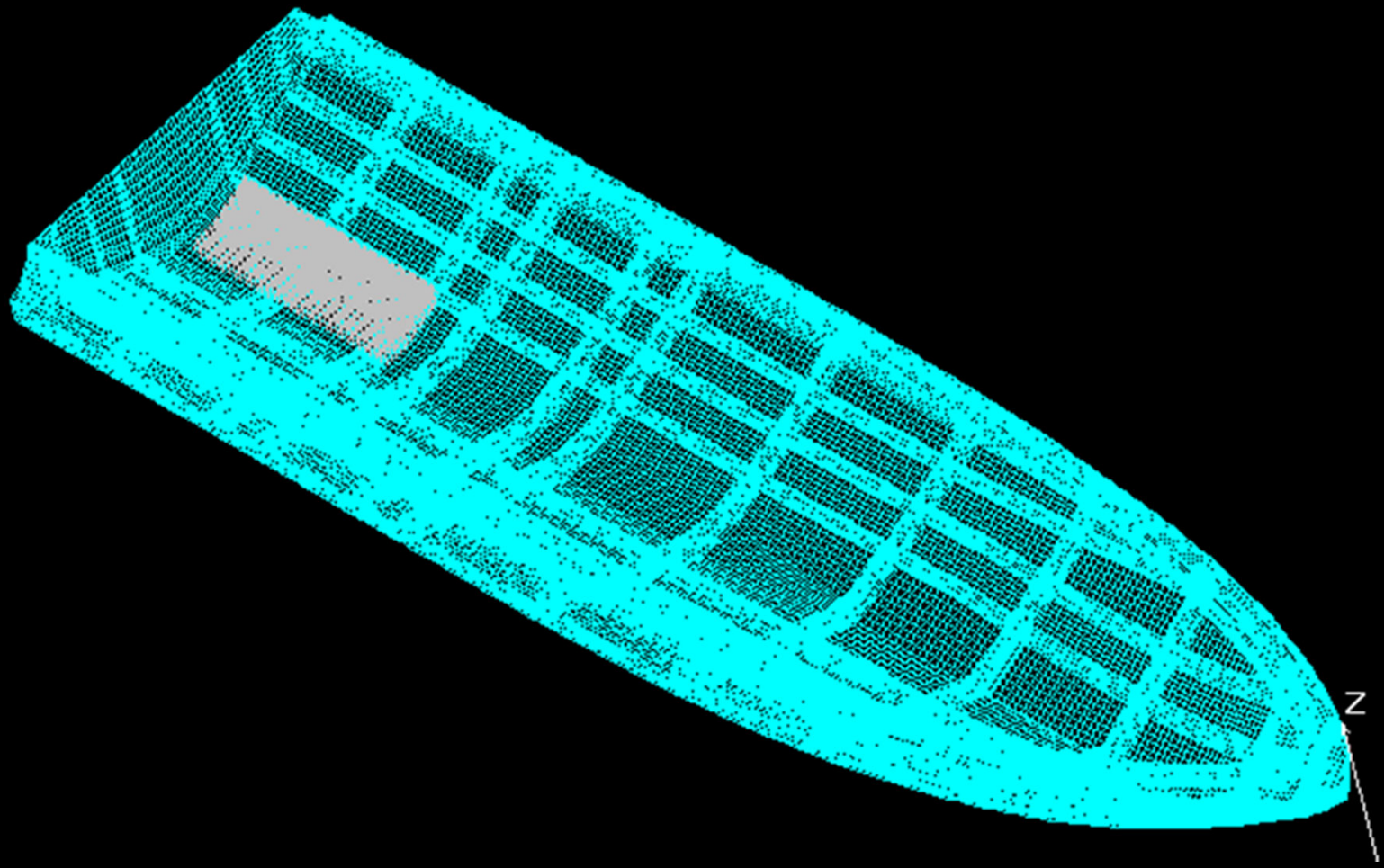
11M Fiberglass Laminate(FG)- FEA Load Cases

Load Case	Load ID	Description	Pressure	Load
1	AI	Aft Inboard, SAS	10psi	--
2	AO	Aft Outboard, SAS	10psi	--
3	AMI	Aft Mid Inboard, SAS	10psi	--
4	AMO	Aft Mid Outboard, SAS	10psi	--
5	FMI	Fwd Mid Inboard, SAS	10psi	--
6	FMO	Fwd Mid Outboard, SAS	10psi	
7	FI	Fwd, Inboard	10psi	
8	TRL	Trailer Load Analysis		51,000 lb

Small Area Pressure Load

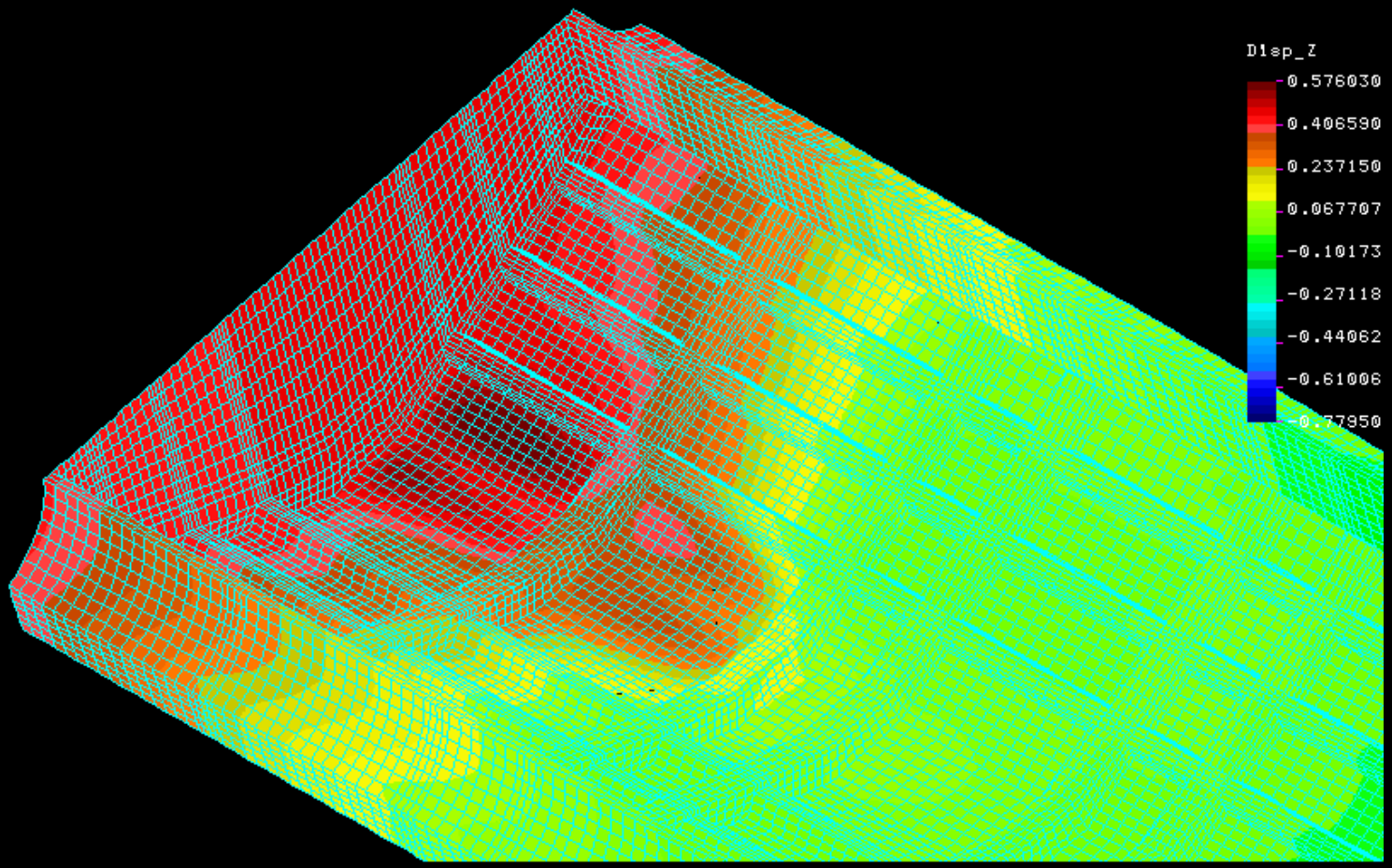
- 10 psi
- Applied between bulkheads
- Applied to two panels and included stringer

LC1- FG -10 psi Pressure Load



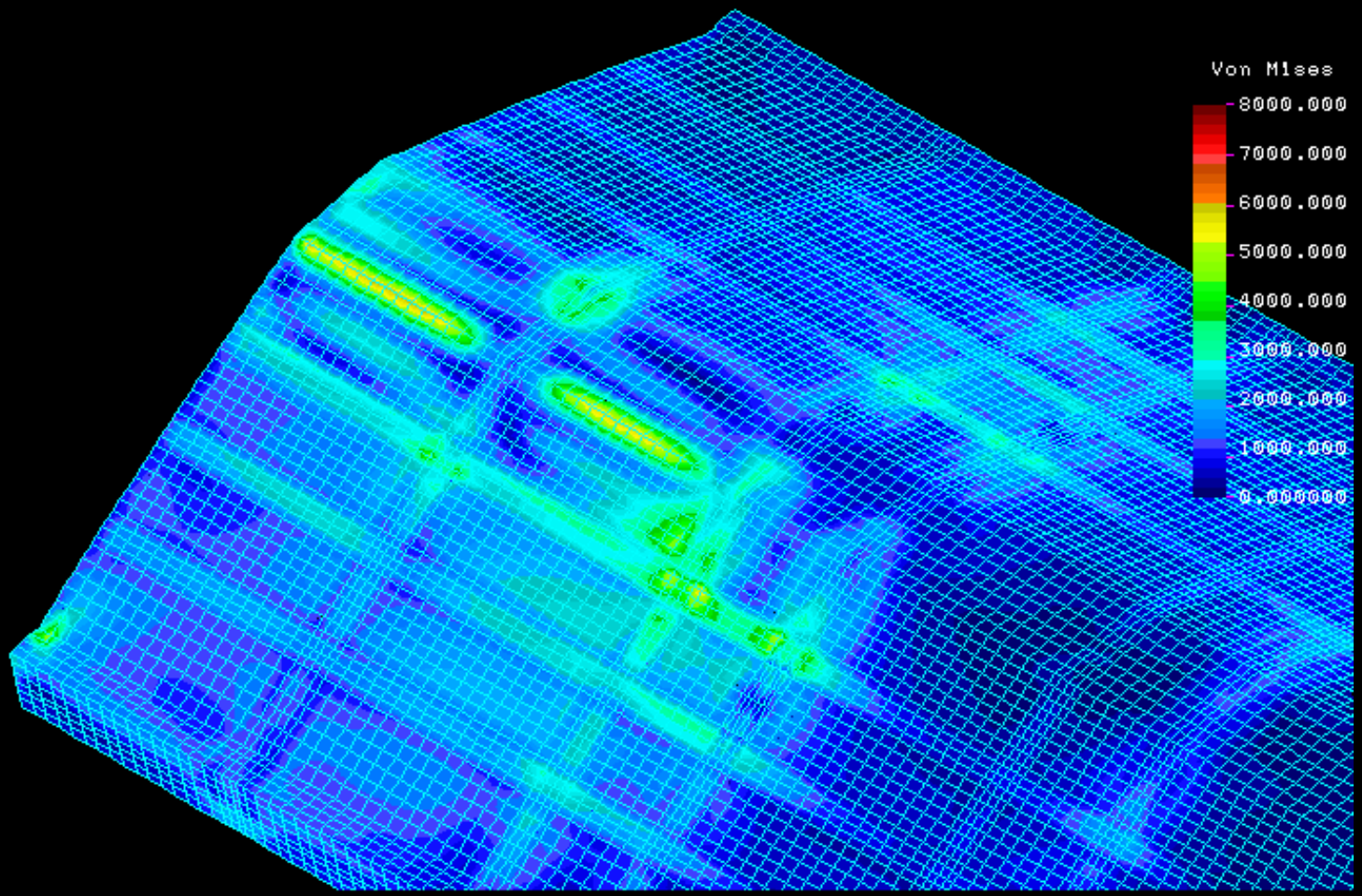
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LC1-FG-Vertical Displacement



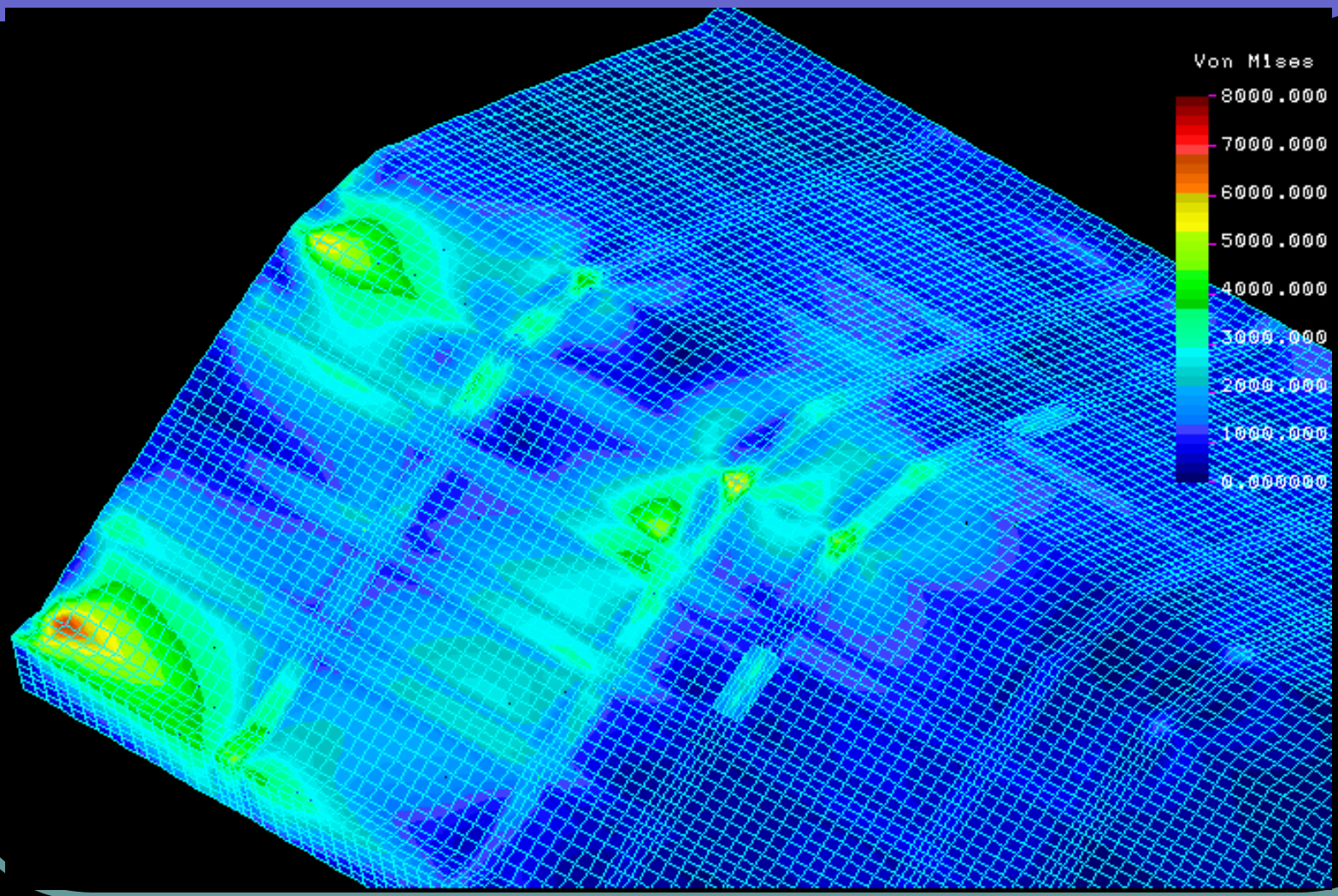
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LC1-FG- Stress Transverse Hull Shell Ply

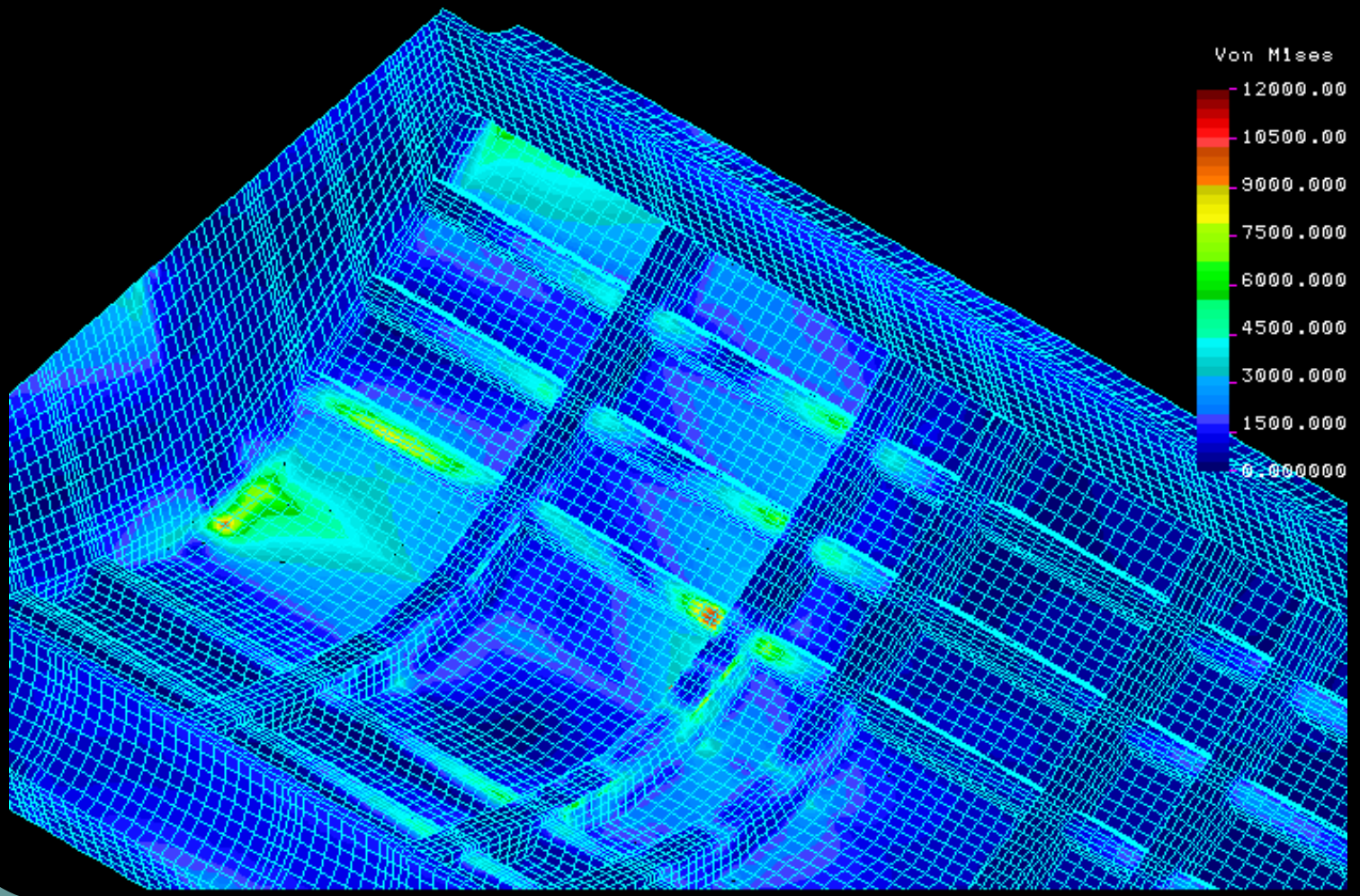


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LC1-FG-Logitudinal Hull Shell Ply Stress



LC1-FG- Longitudinal Stringer Cap Stress



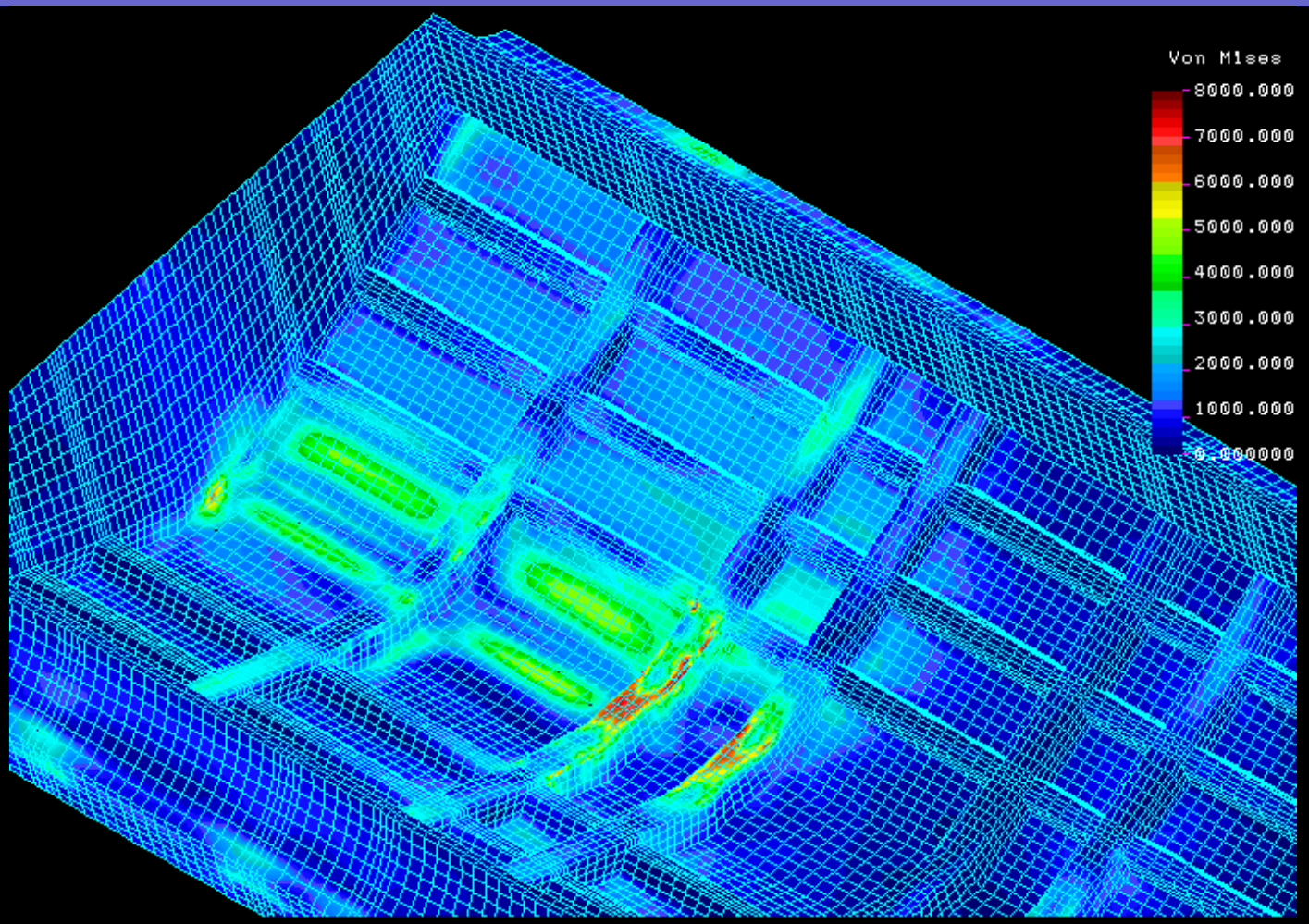
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LC1-FG- Transverse Frame Cap Stress



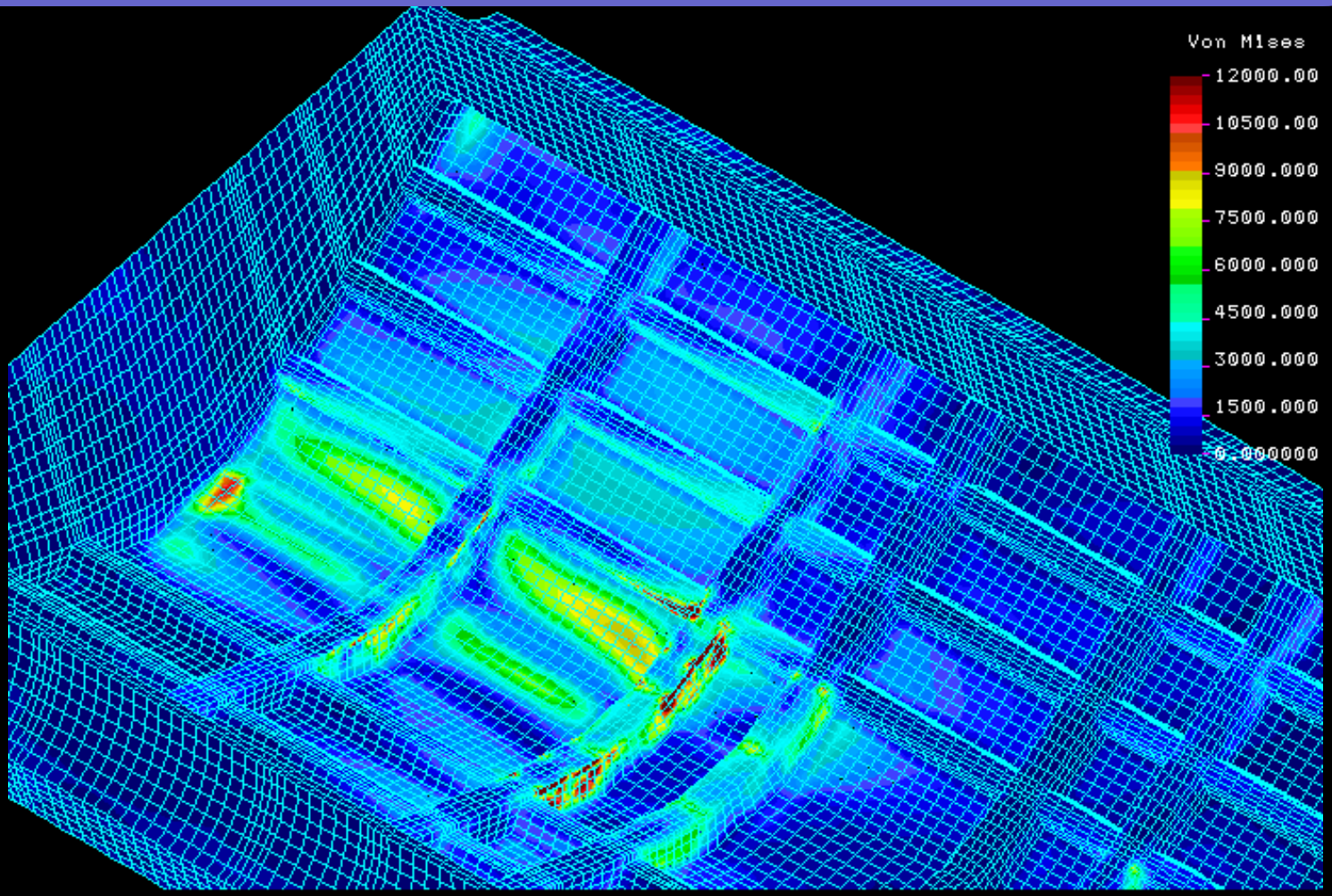
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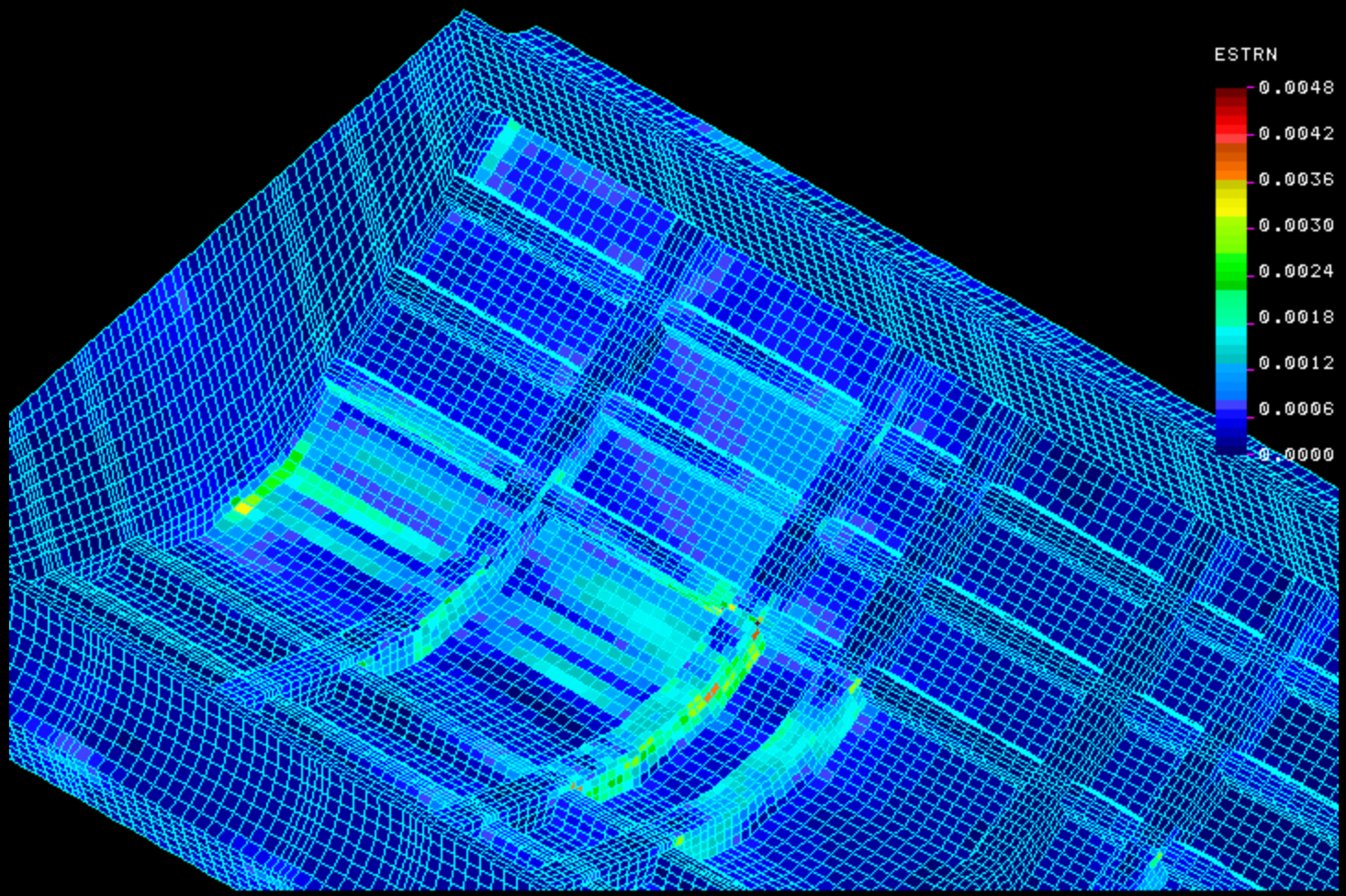
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LC1-FG- 45 Ply Tab and Side Wall Stress



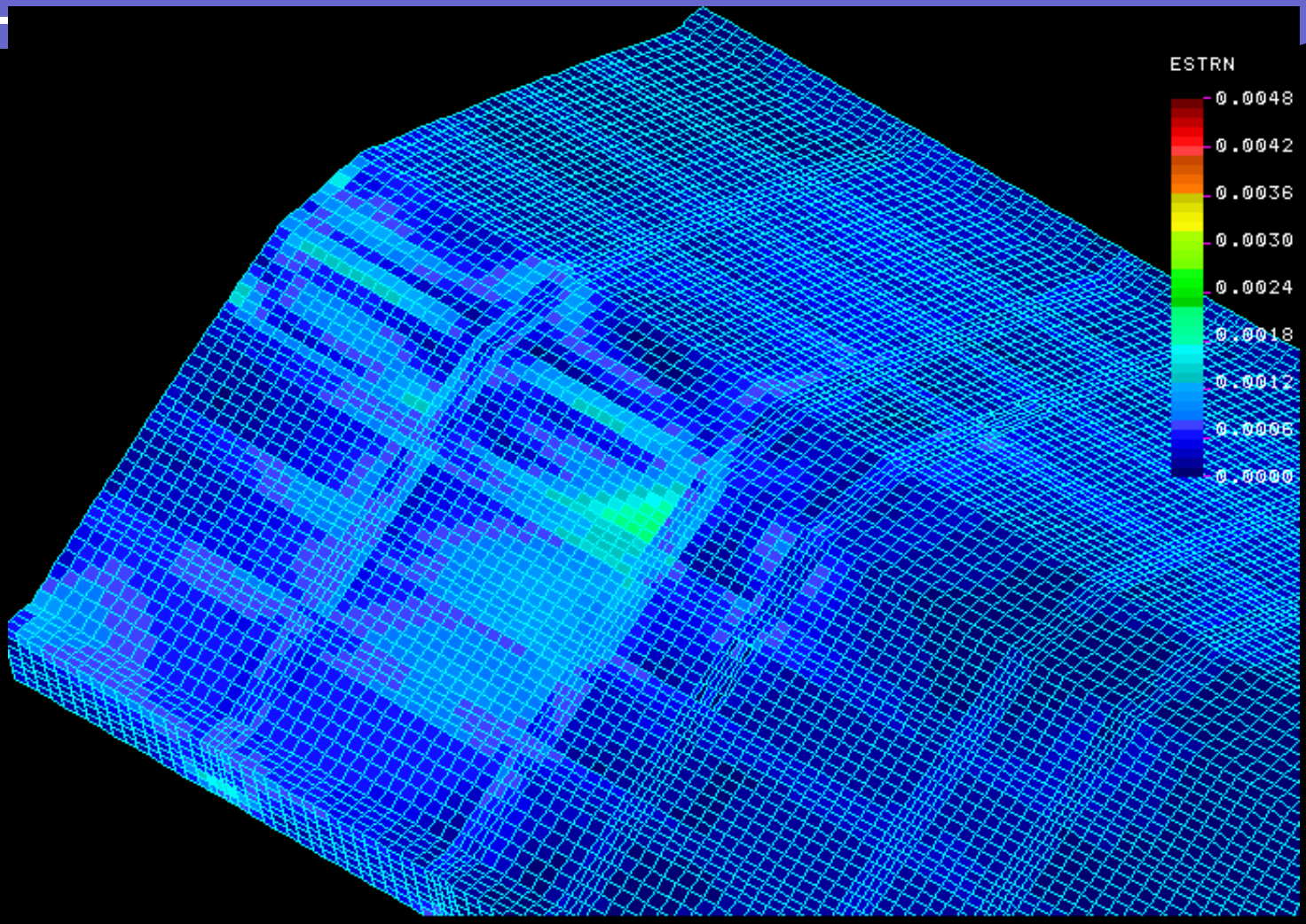
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LC1-FG- Inside Surface Strain



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LC1-FG- Outside Surface Strain

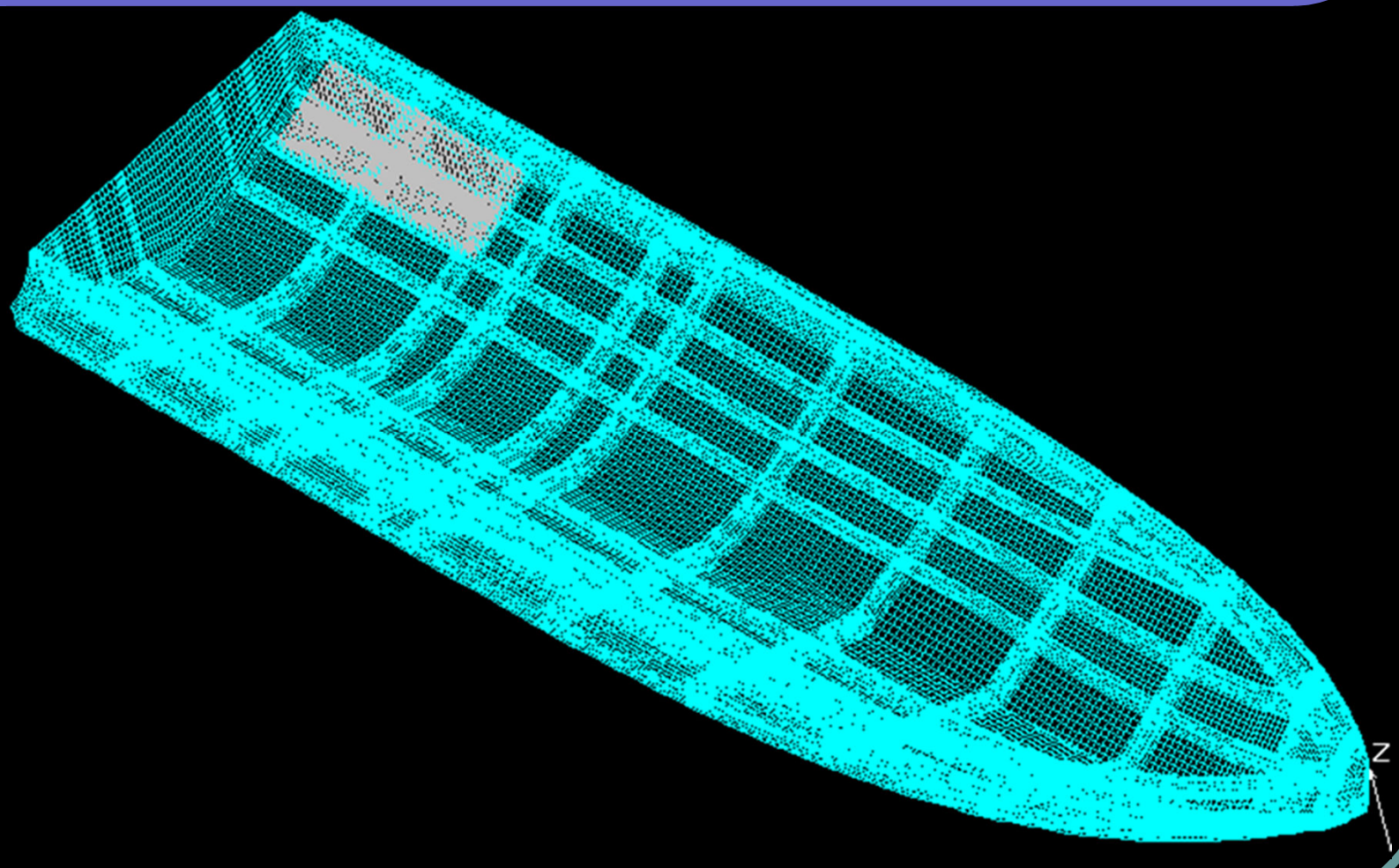


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LC1-FG- AI- Summary

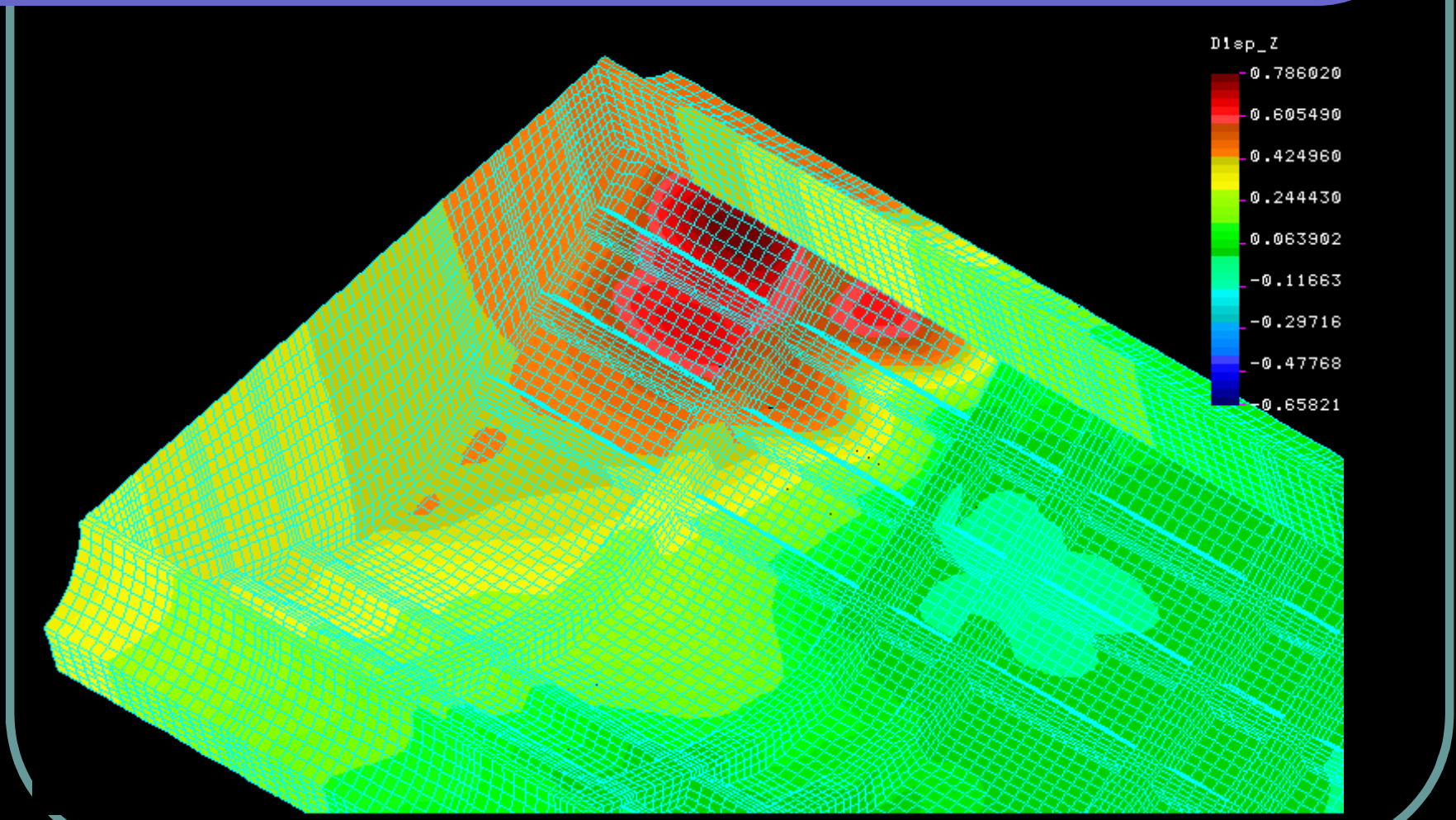
- Hull range of deflection 1.36 in.
- Maximum Hull strain 0.0015 in/in
- Maximum Hull stress 5,500
- Maximum framing strain 0.004
- Maximum framing stress 12,000 psi

LC2-FG- AO-10 psi Pressure Load



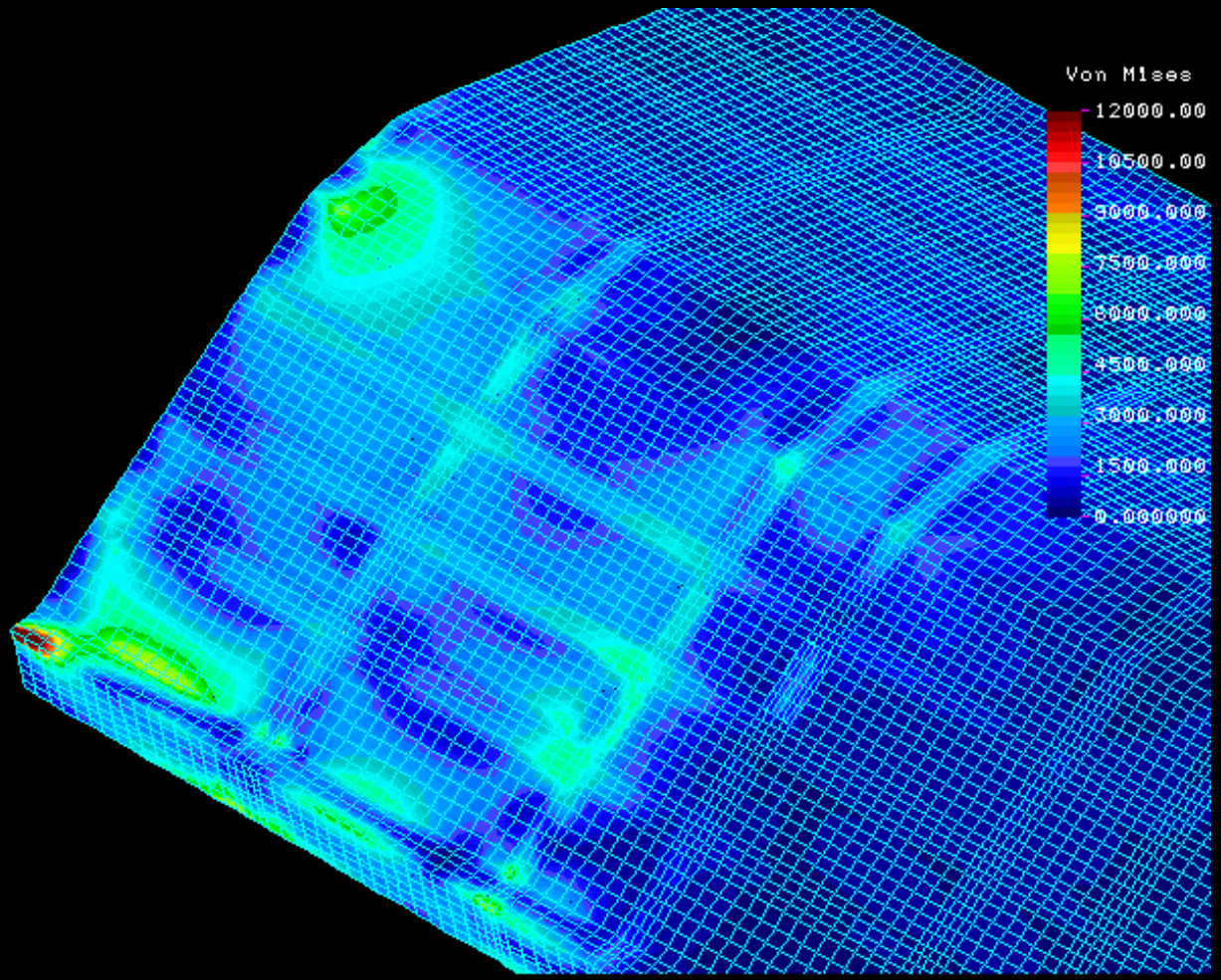
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LC2-FG-Vertical Displacement



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LC2-FG- Stress Transverse Hull Shell Ply



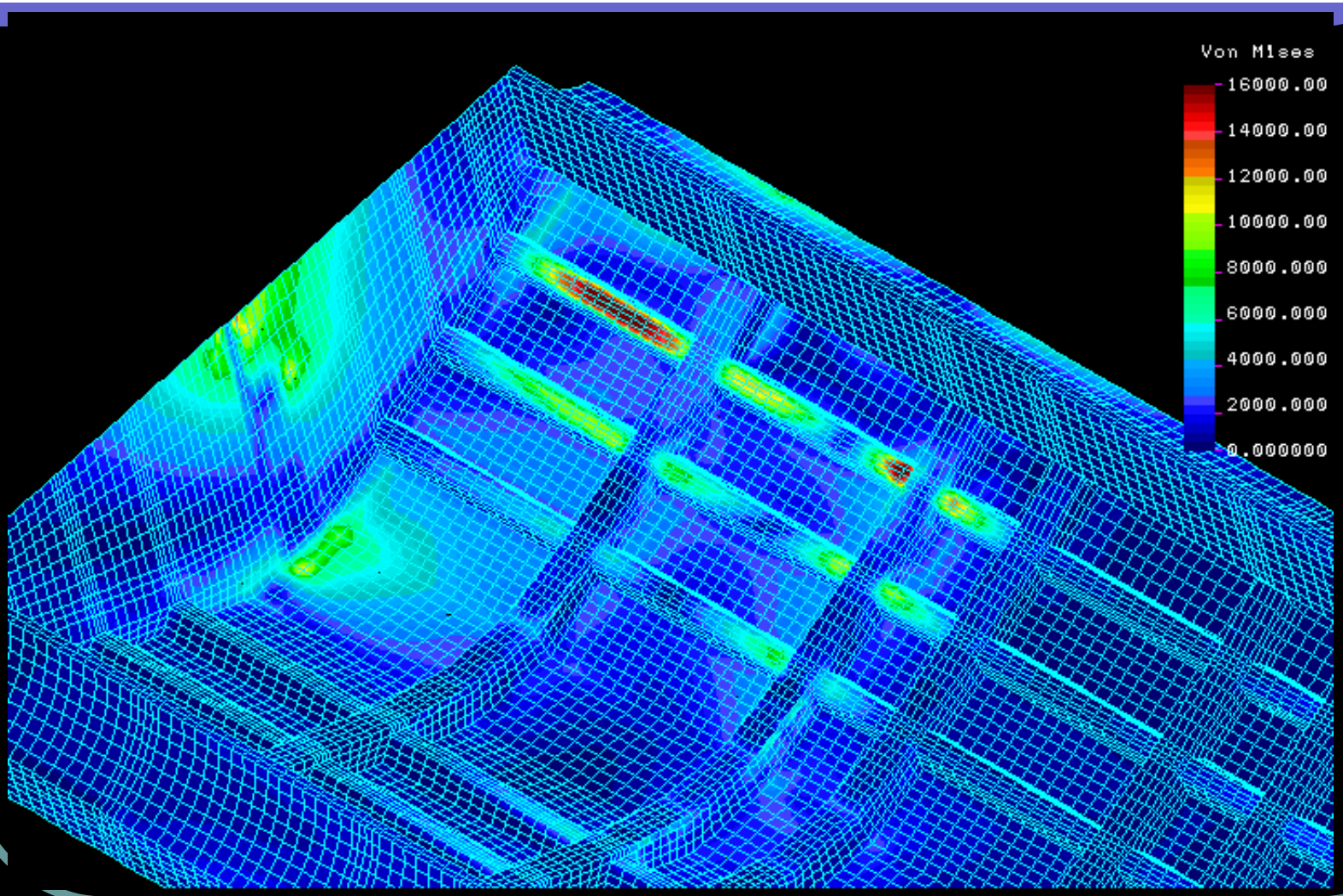
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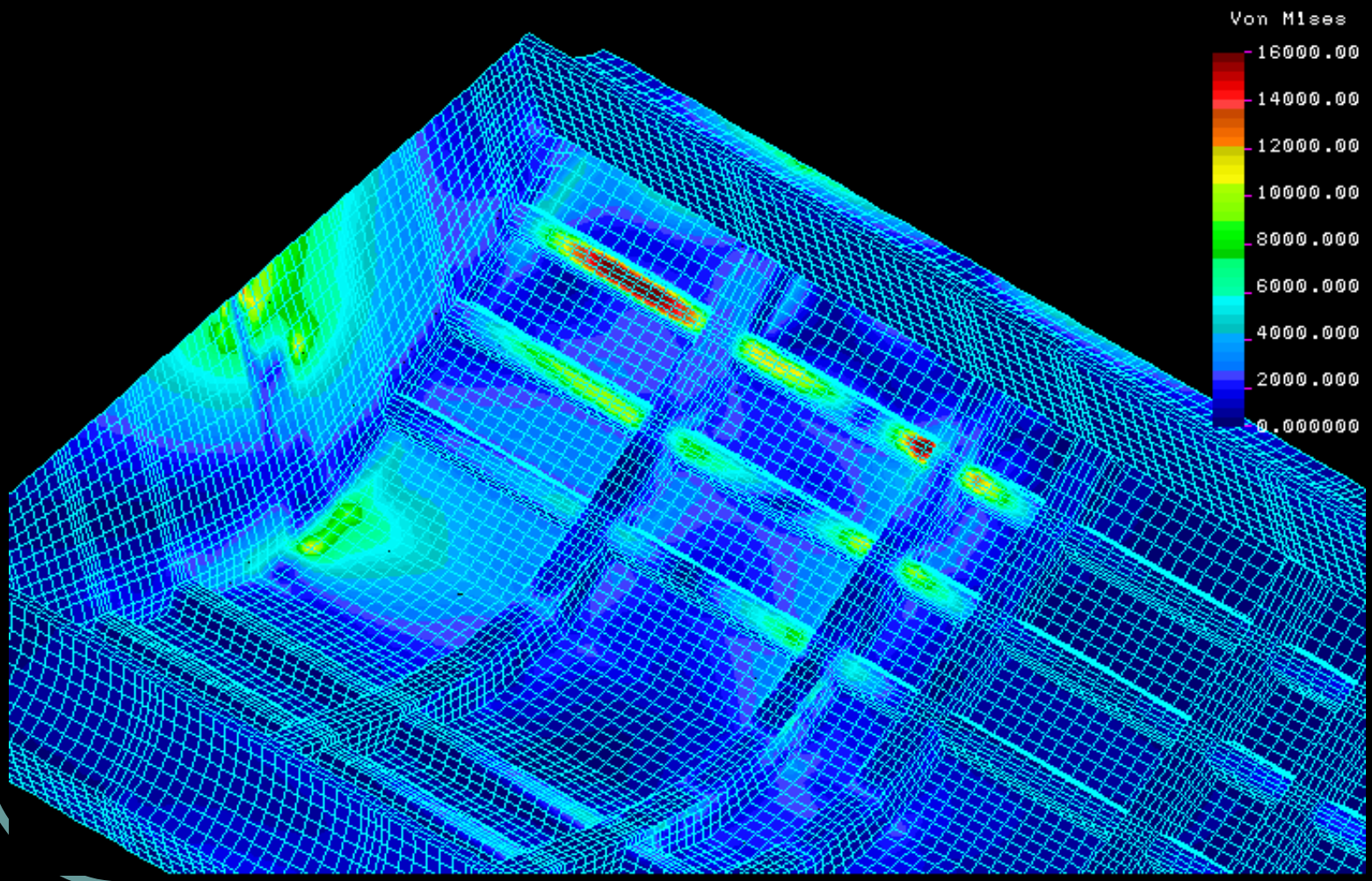
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LC2-FG-Logitudinal Hull Shell Ply Stress



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LC2-FG- Longitudinal Stringer Cap Stress



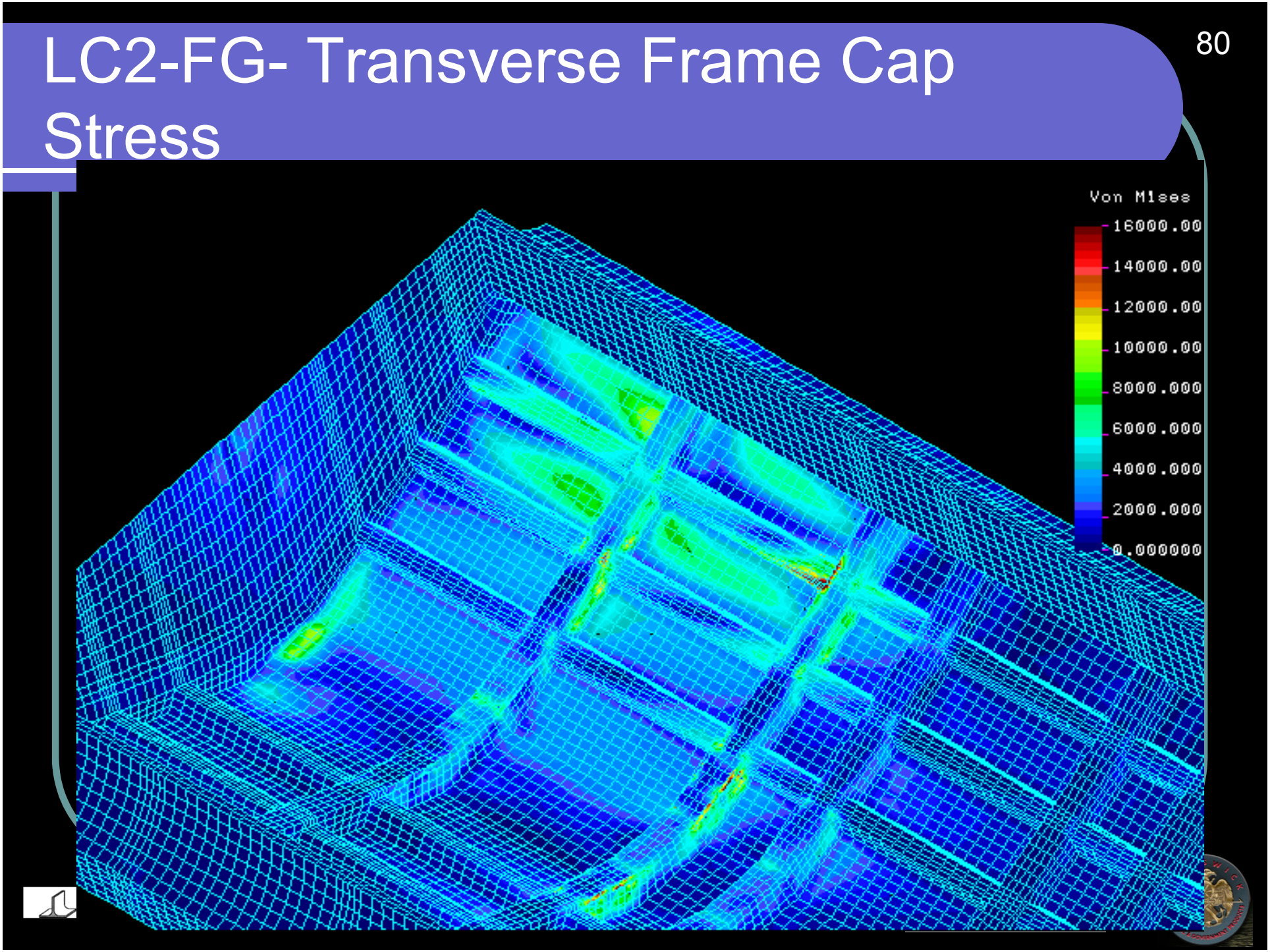
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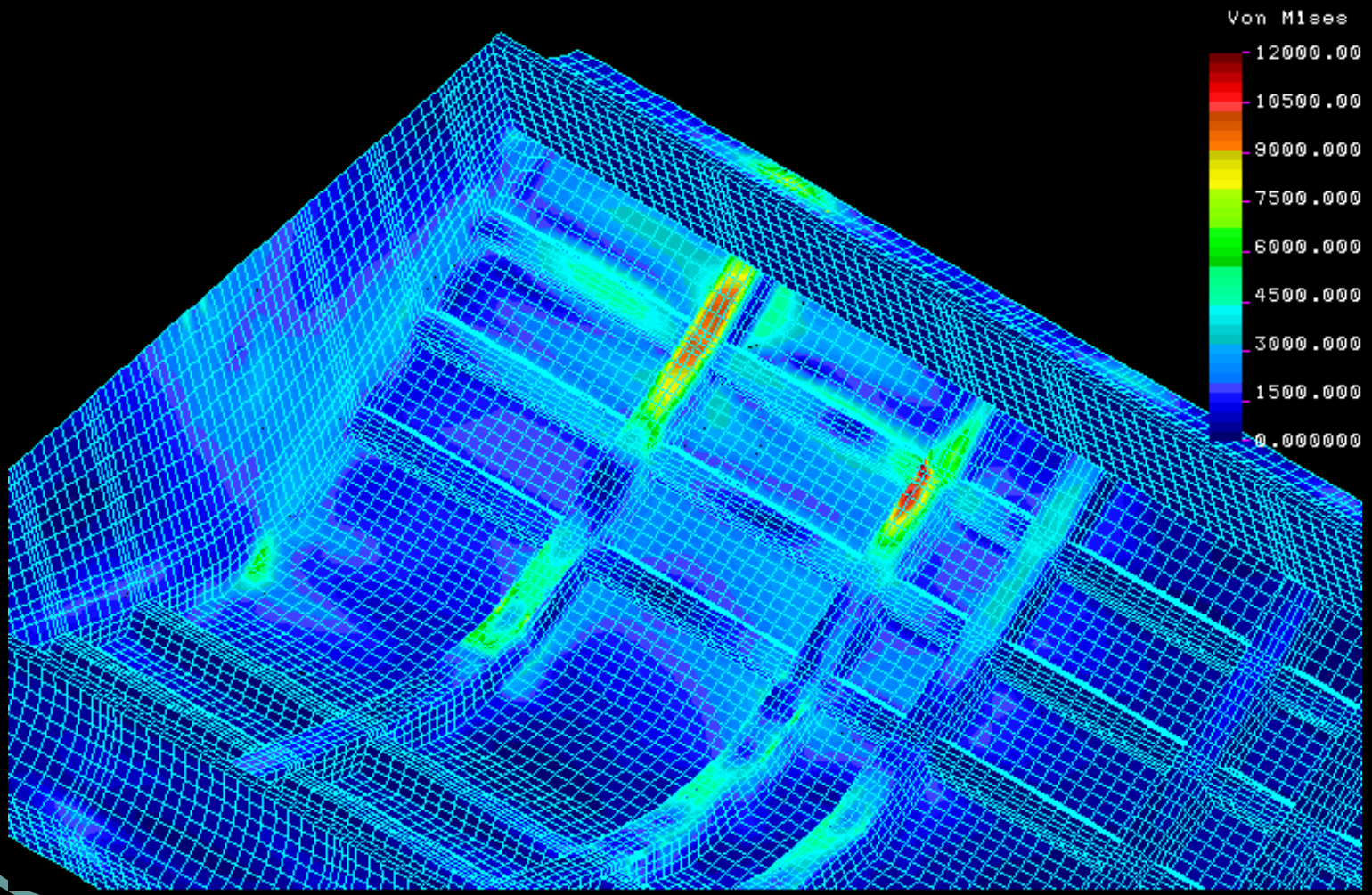
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LC2-FG- Transverse Frame Cap Stress



LC2-FG- 45 Ply Tab and Side Wall Stress



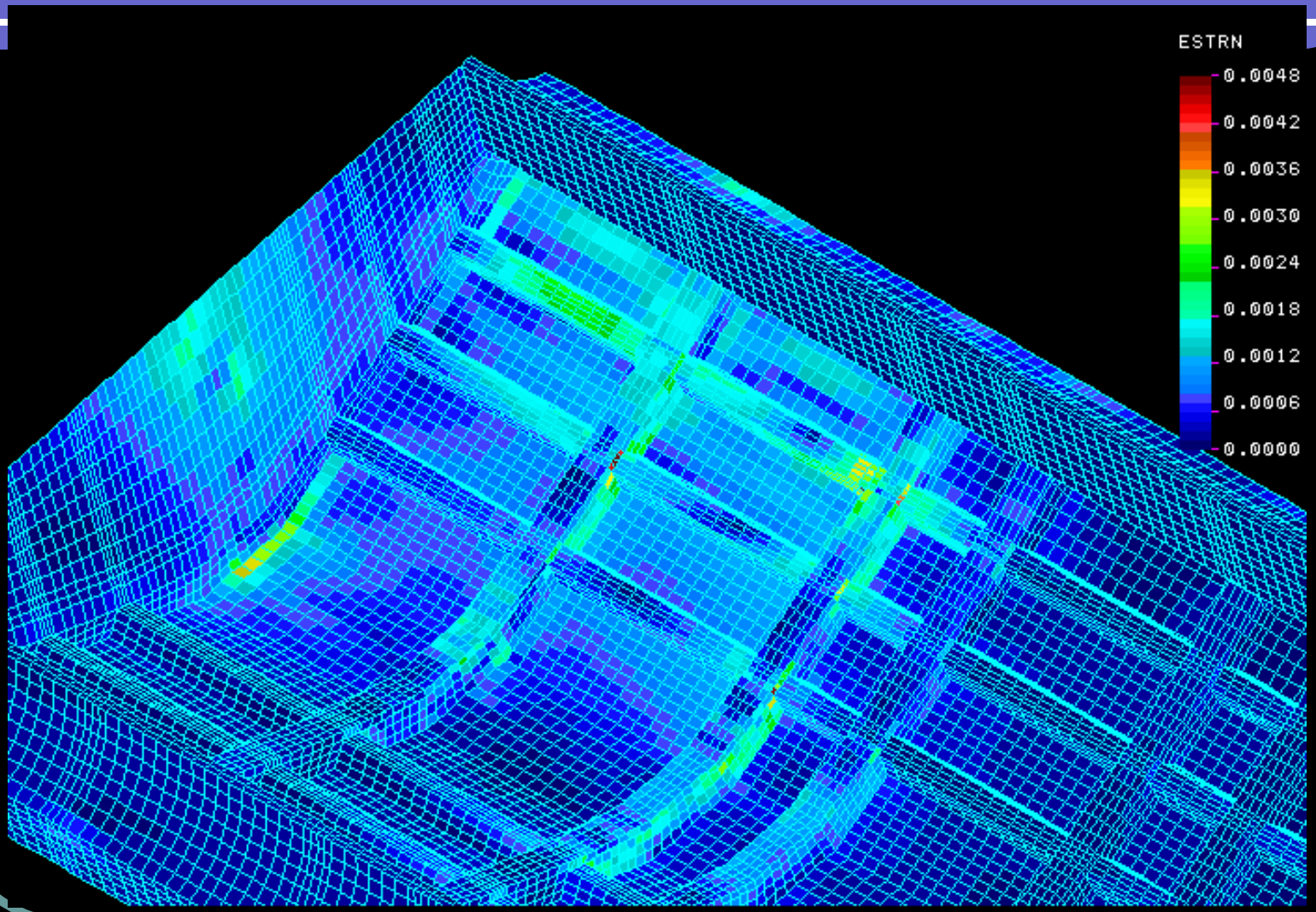
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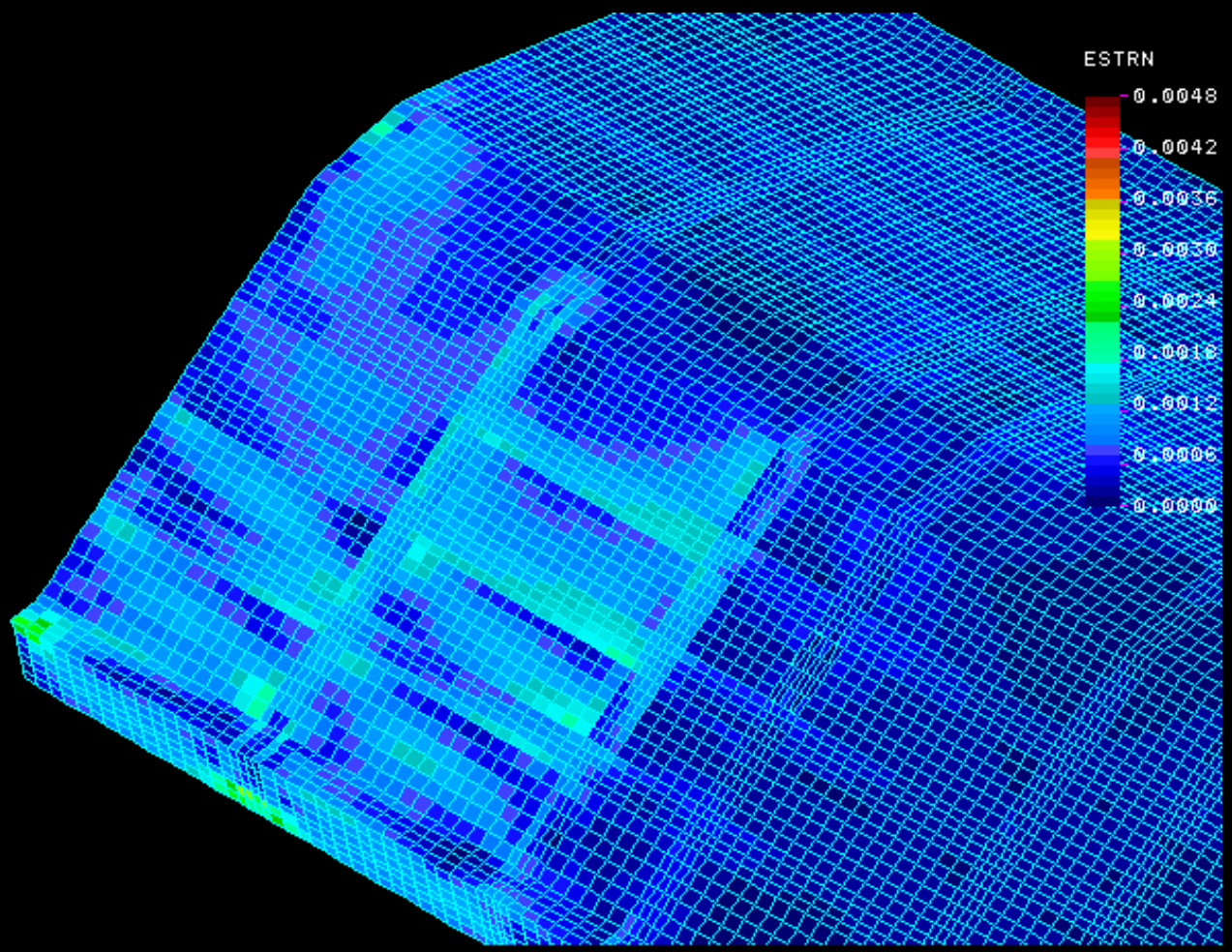
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LC2-FG- Inside Surface Strain



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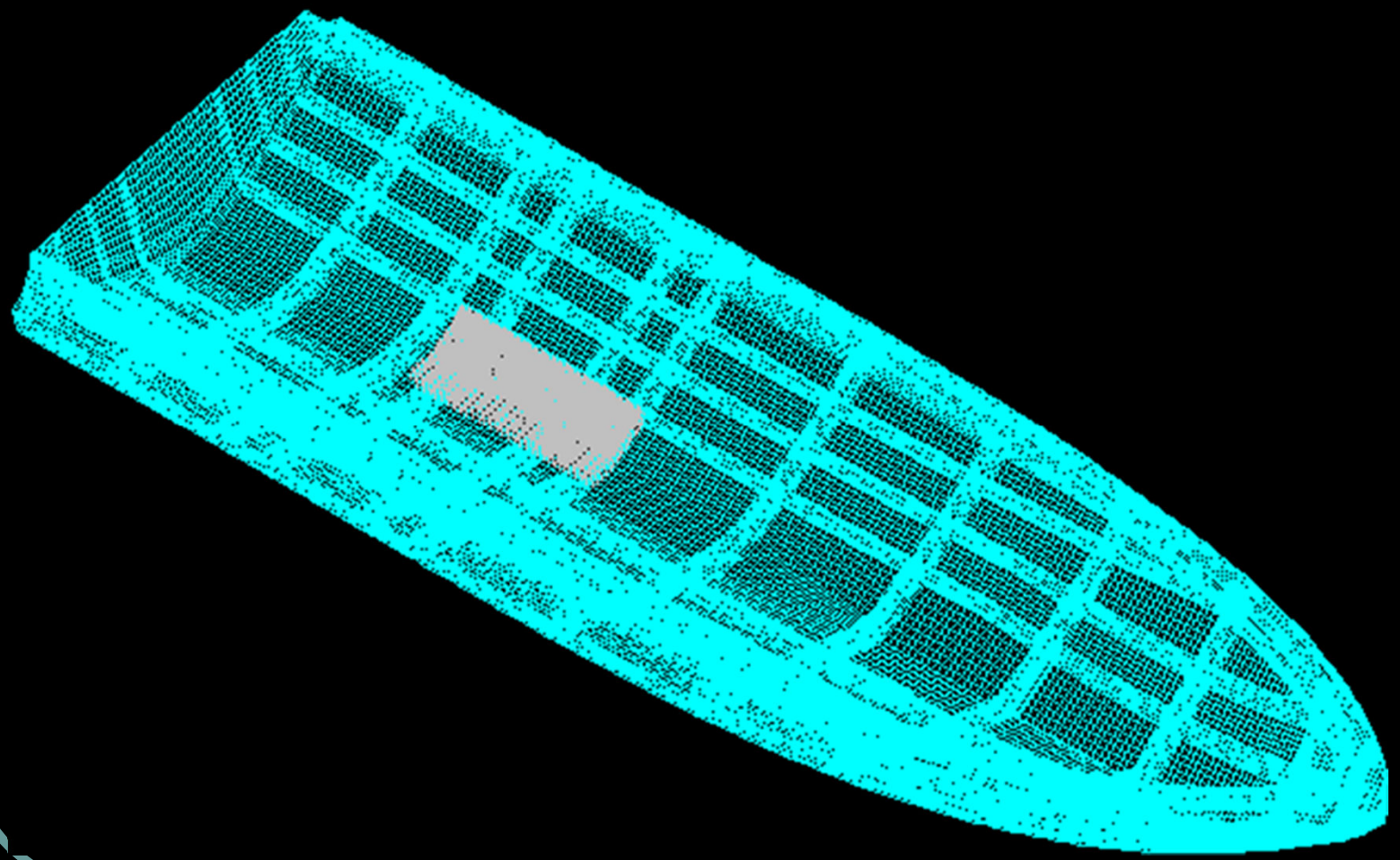
LC2-FG- Outside Surface Strain



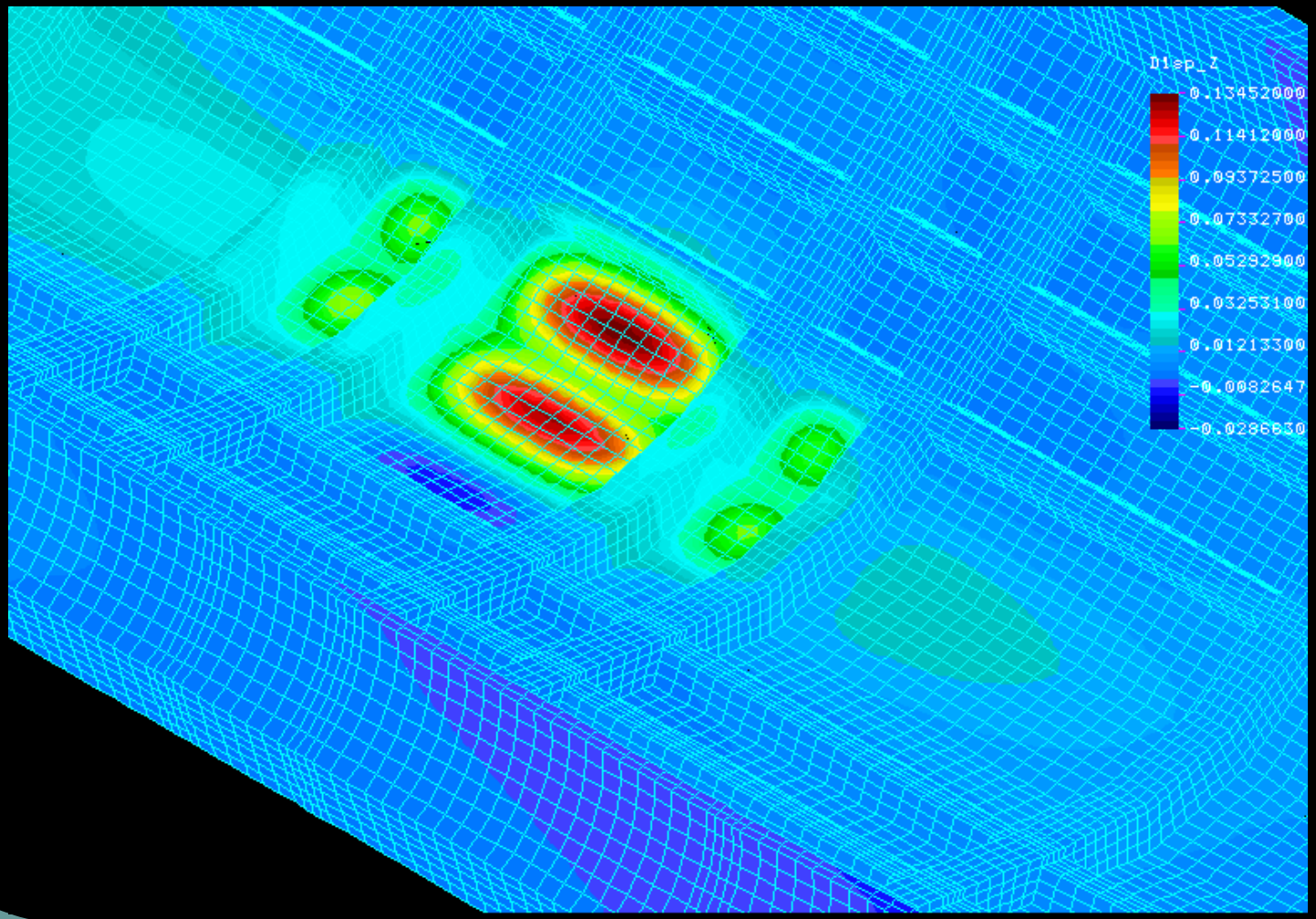
LC2-FG AO- Summary

- Hull range of deflection to 1.45 in.
- Maximum Hull strain 0.0018 in/in
- Maximum Hull stress 8,500
- Maximum framing strain 0.0036
- Maximum framing stress 16,000 psi

LC3-FG AMI-10 psi Pressure Load

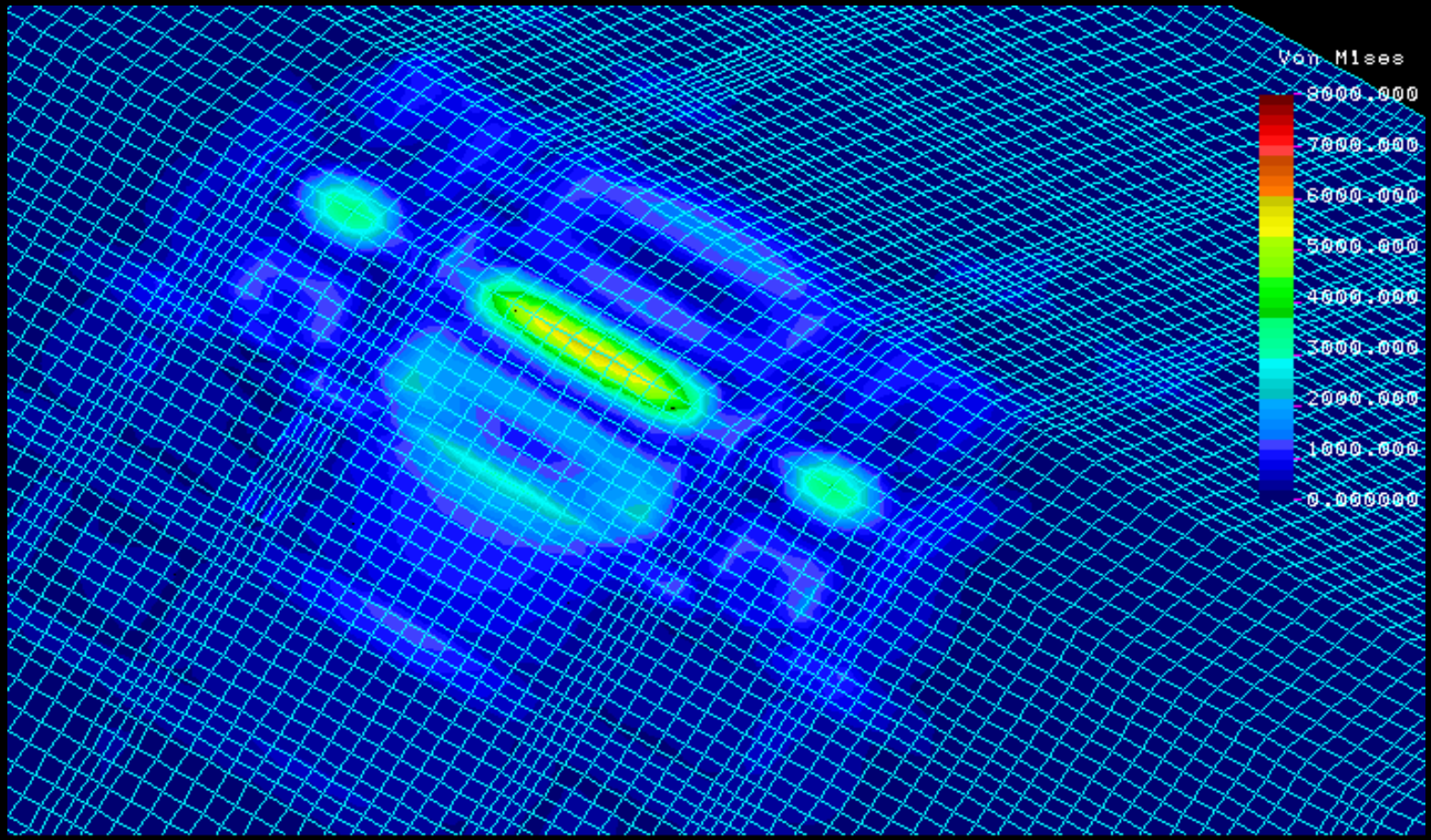


LC3- FG-Vertical Displacement



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LC3-FG- Transverse Hull Shell Ply Stress



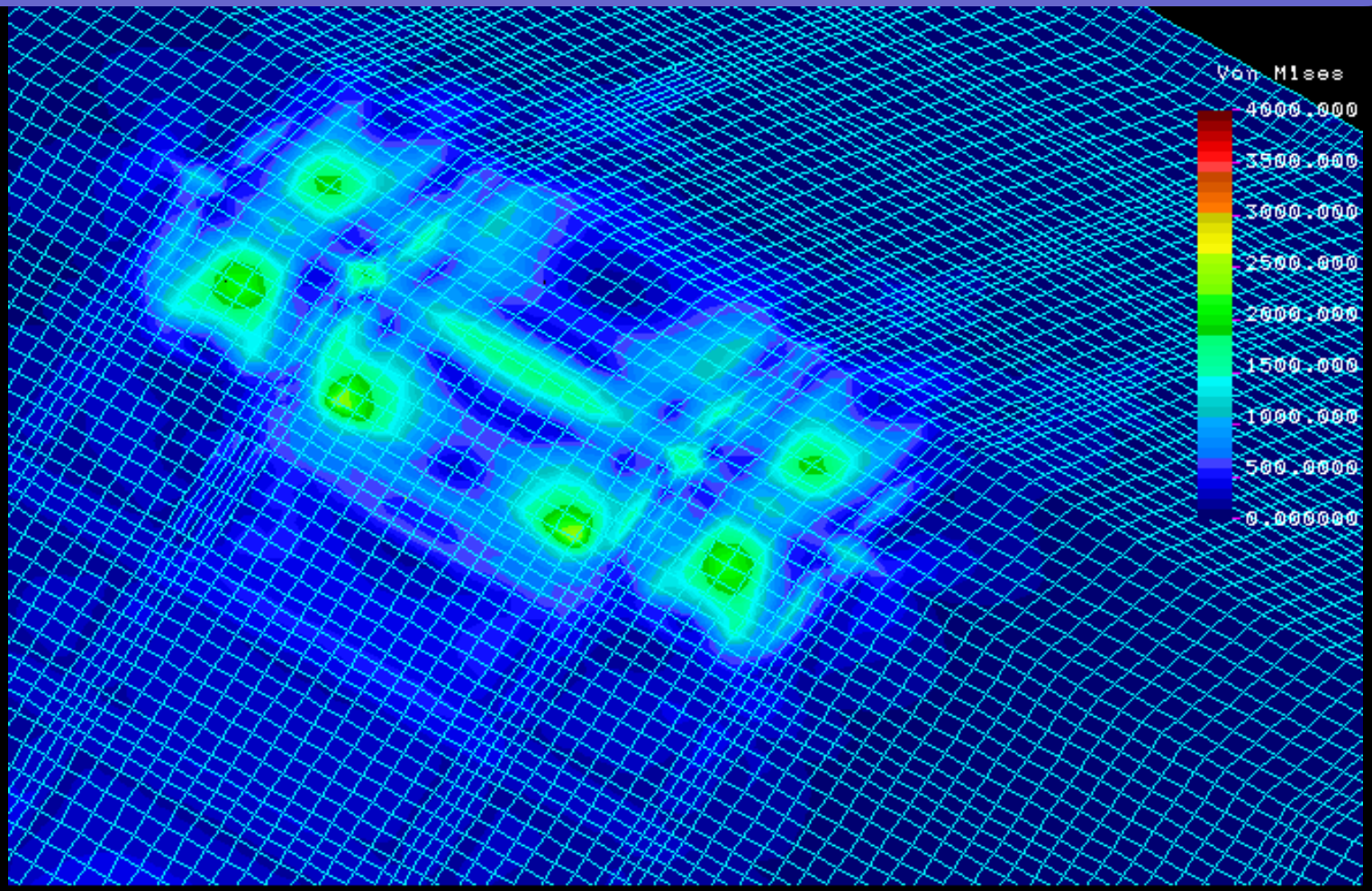
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LC3-FG-Logitudinal Hull Shell Ply Stress



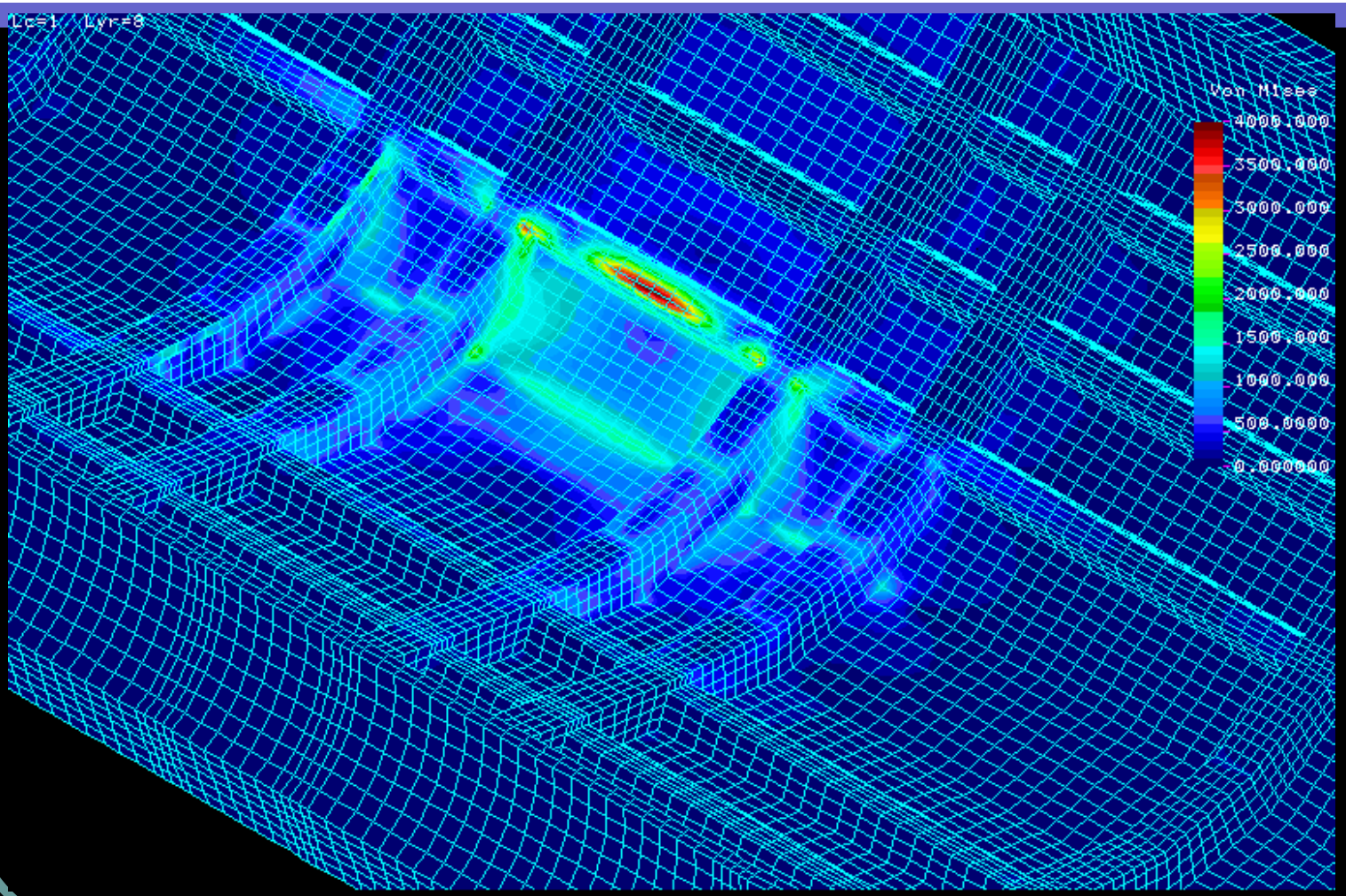
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LC3-FG- Longitudinal Stringer Cap Stress



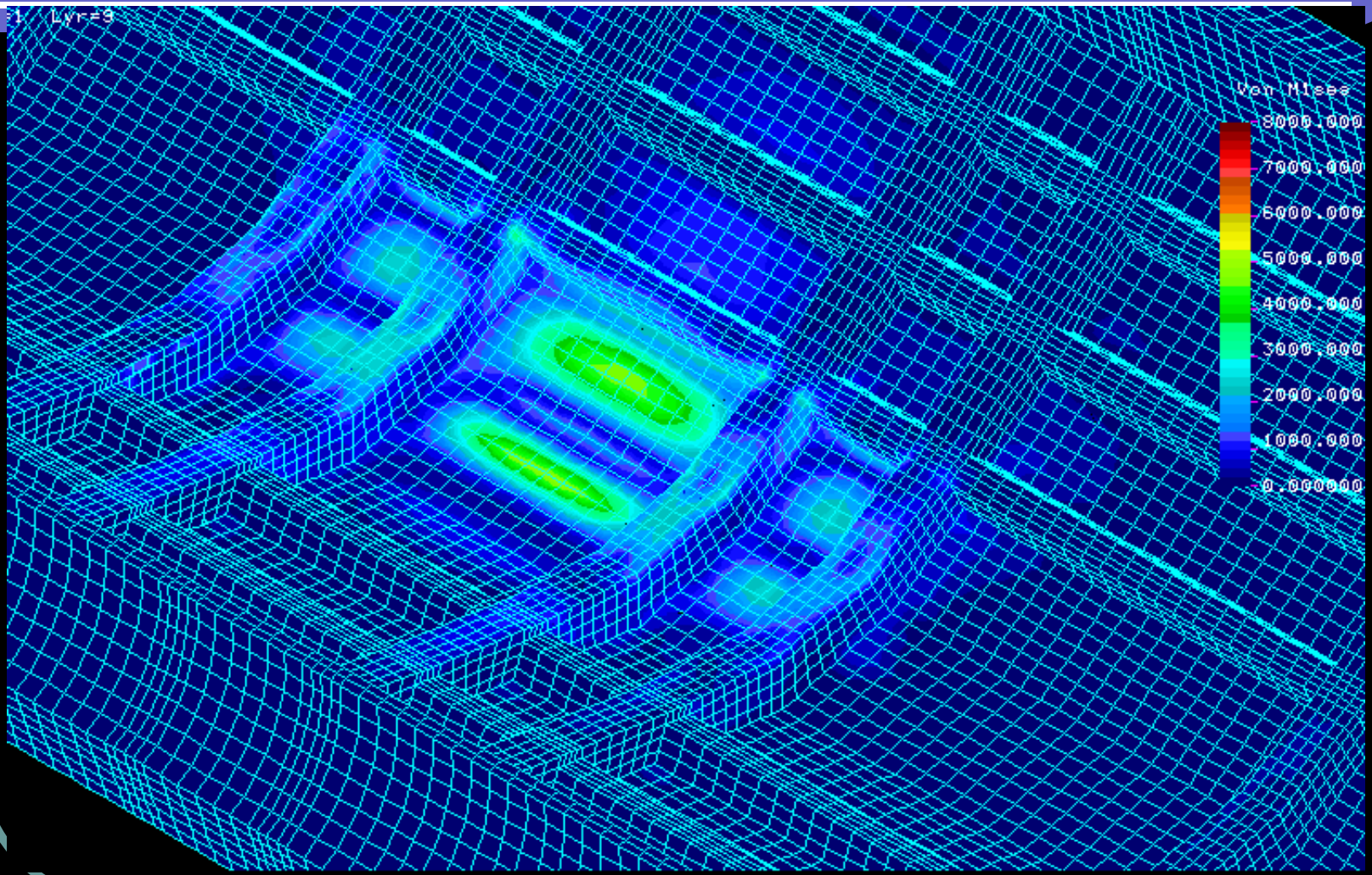
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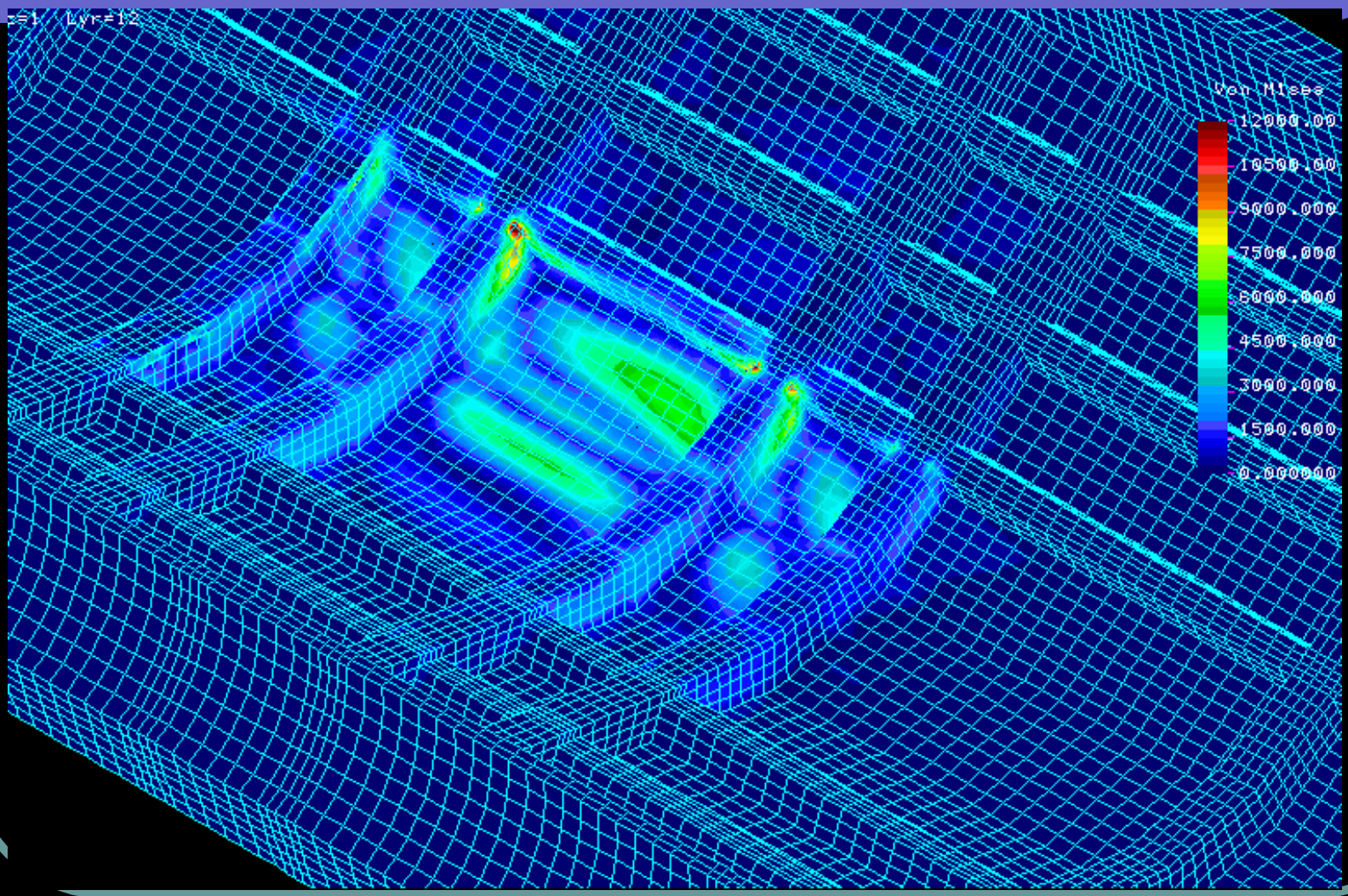
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LC3-FG- Transverse Frame Cap Stress

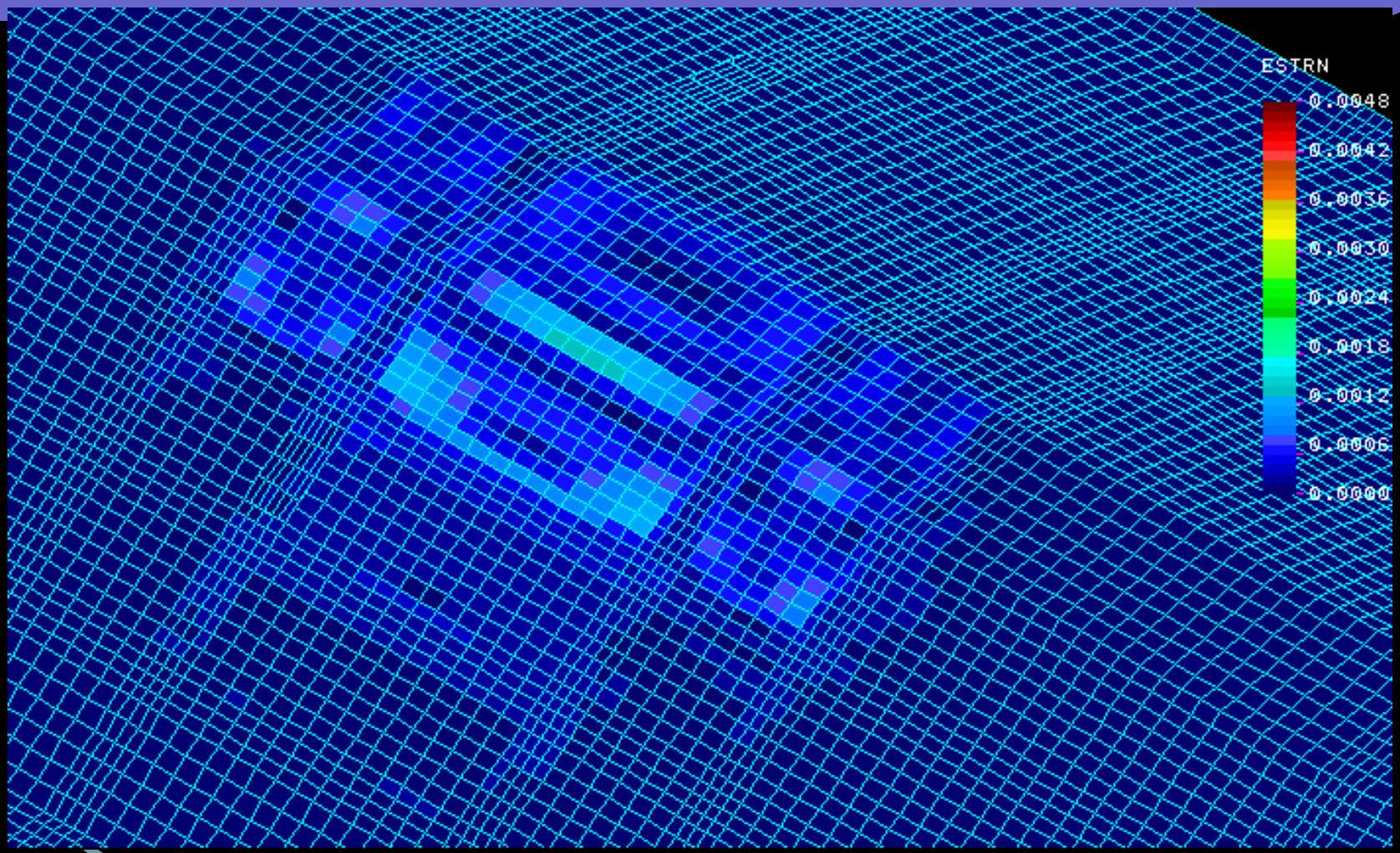


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LC3-FG- 45 Ply Tab and Side Wall Stress

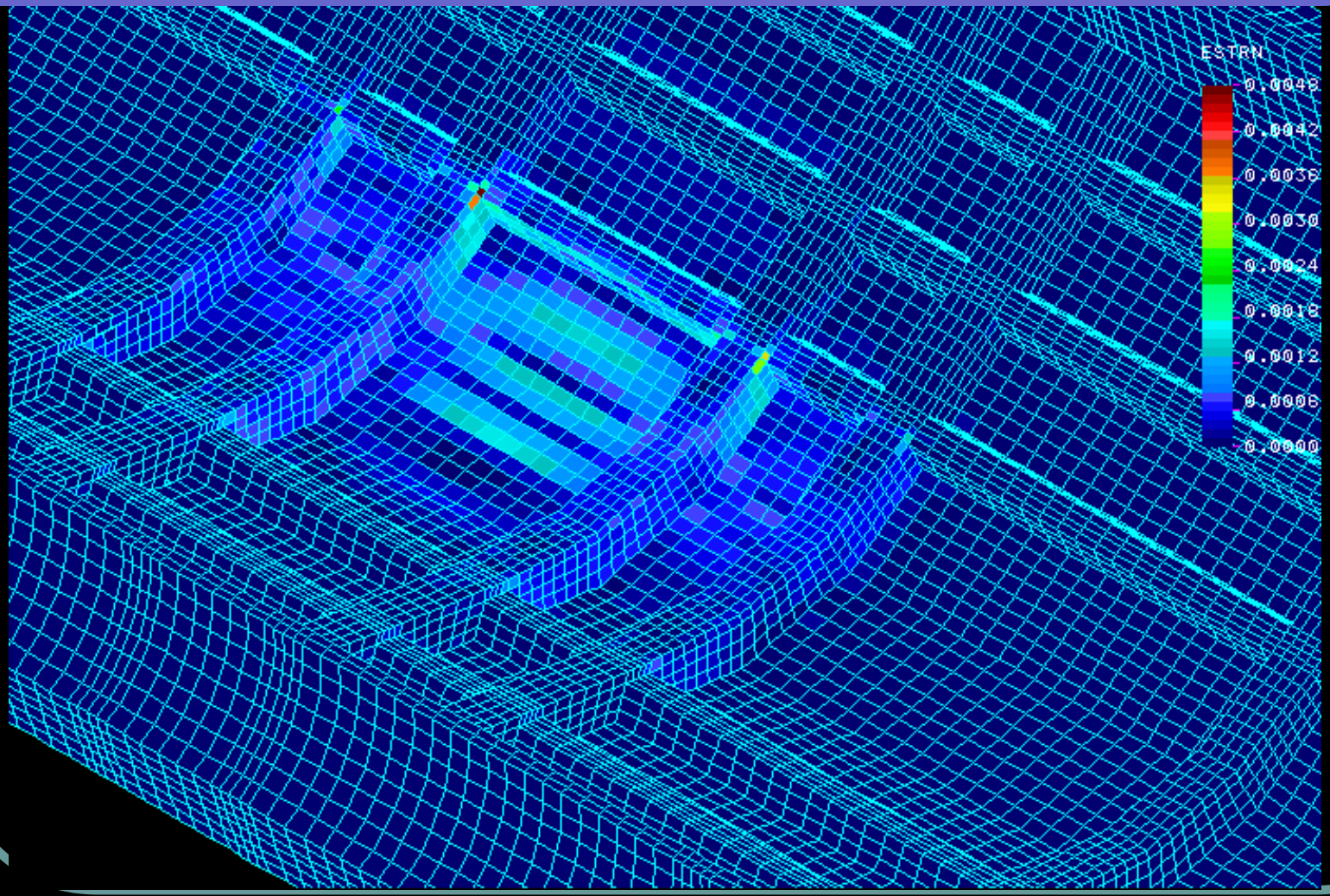


LC3-FG- Inside Surface Strain



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LC3-FG- Outside Surface Strain



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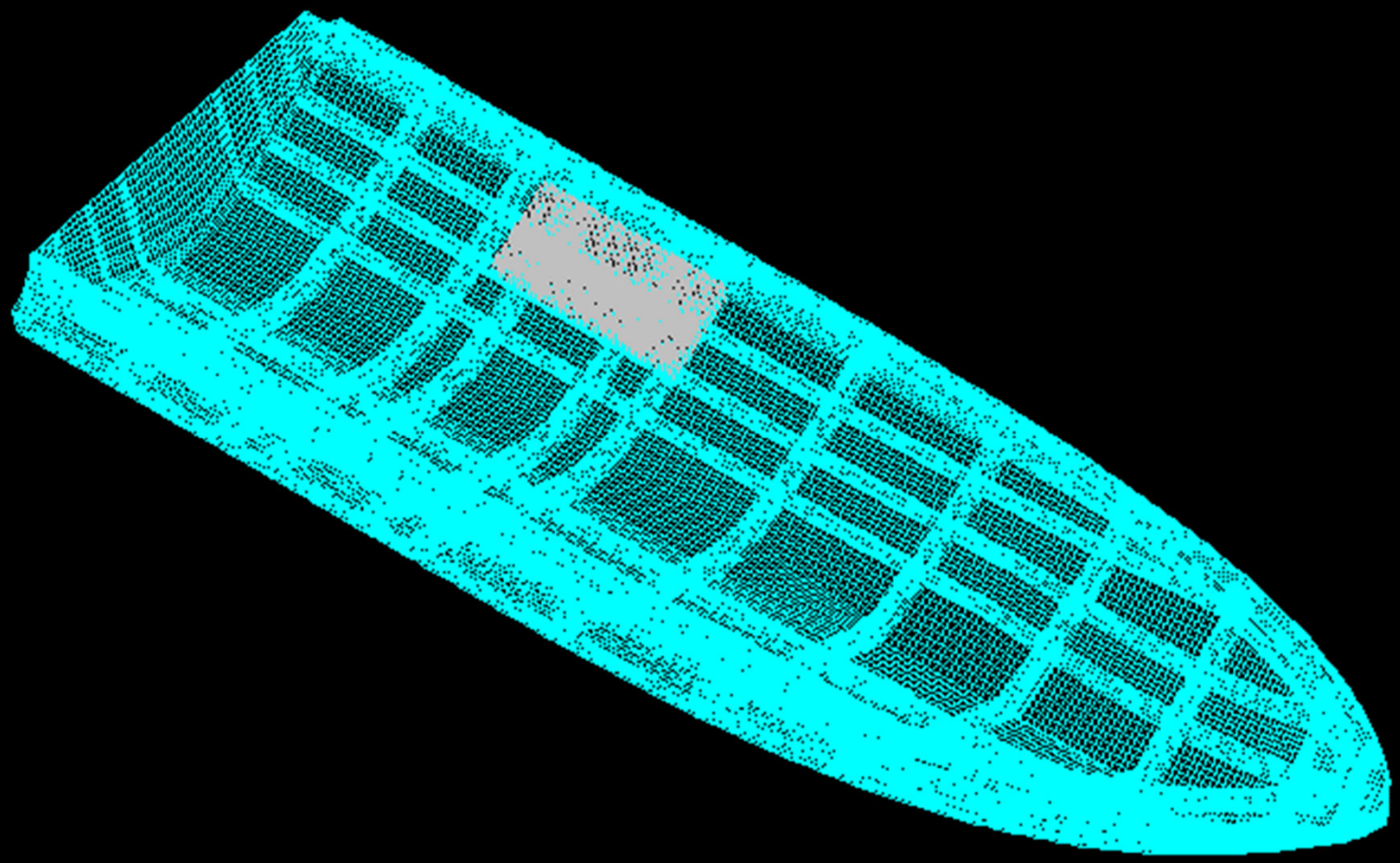
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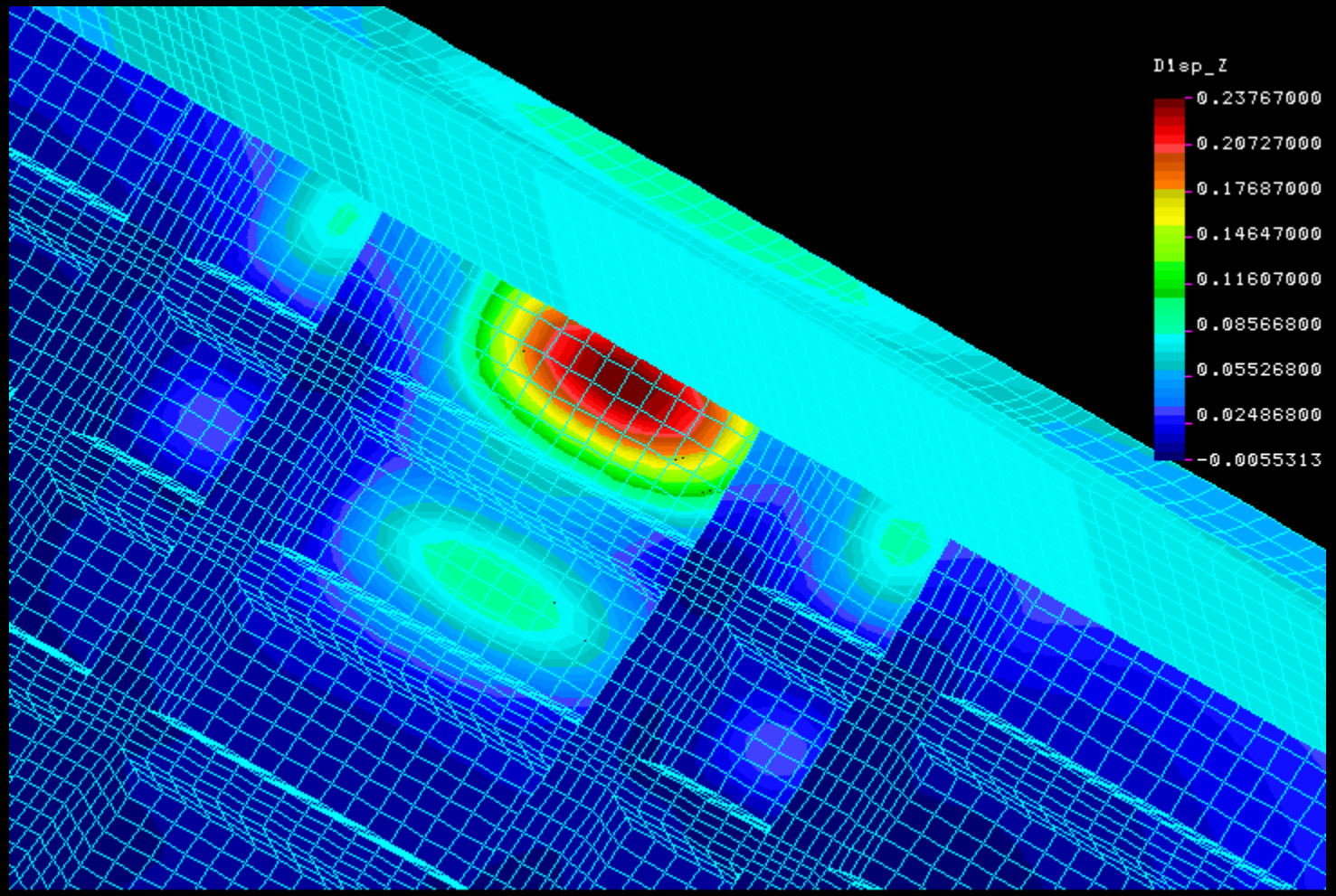
LC3FG-AMI- Summary

- Hull range of deflection to 0.17 in.
- Maximum Hull strain 0.0012 in/in
- Maximum Hull stress 5,500
- Maximum framing strain 0.002
- Maximum framing stress 9,000 psi

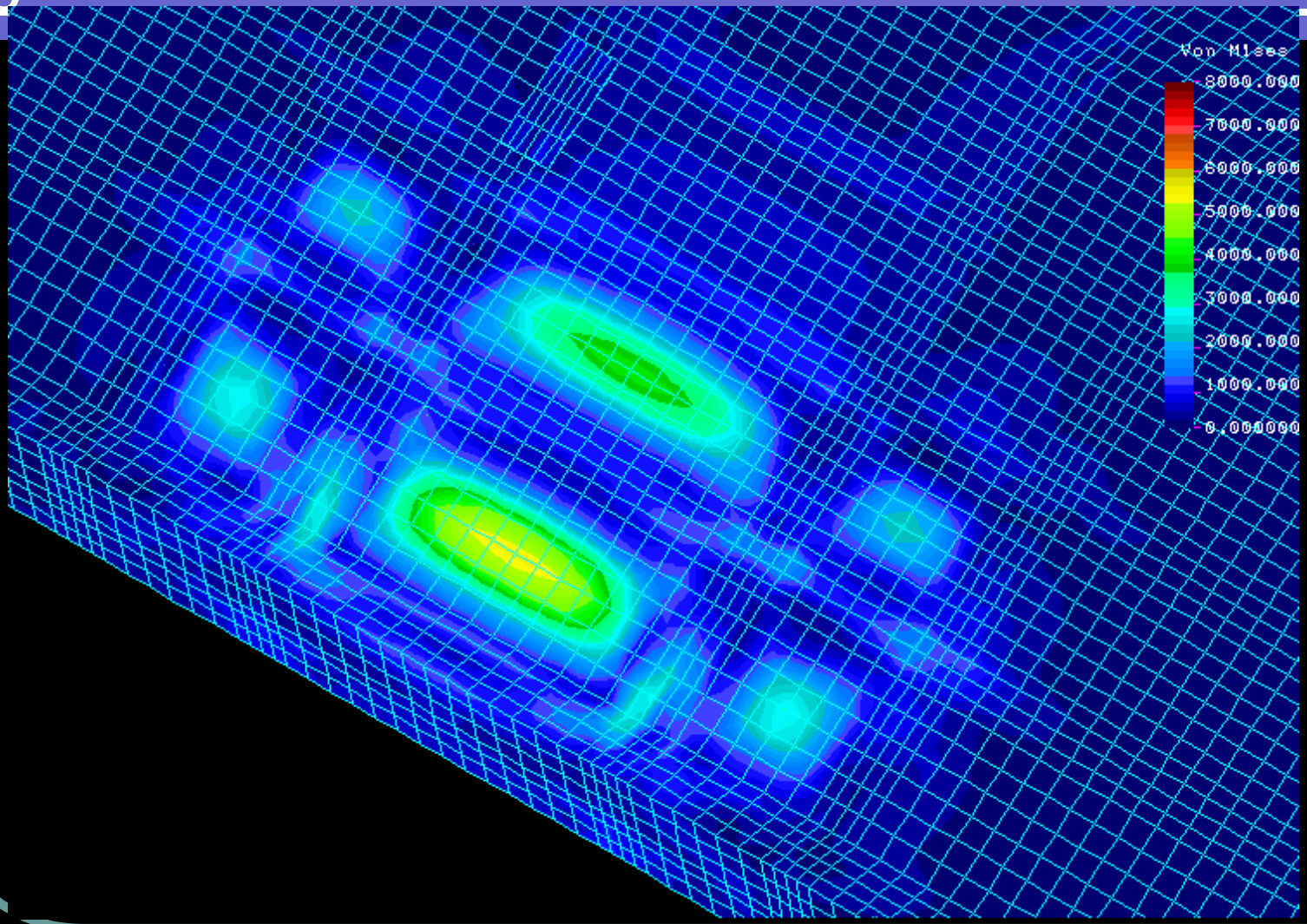
LC4FG- AMO-10 psi Pressure Load



LC4-FG-Vertical Displacement



LC4-FG- Stress Transverse Hull Shell Ply



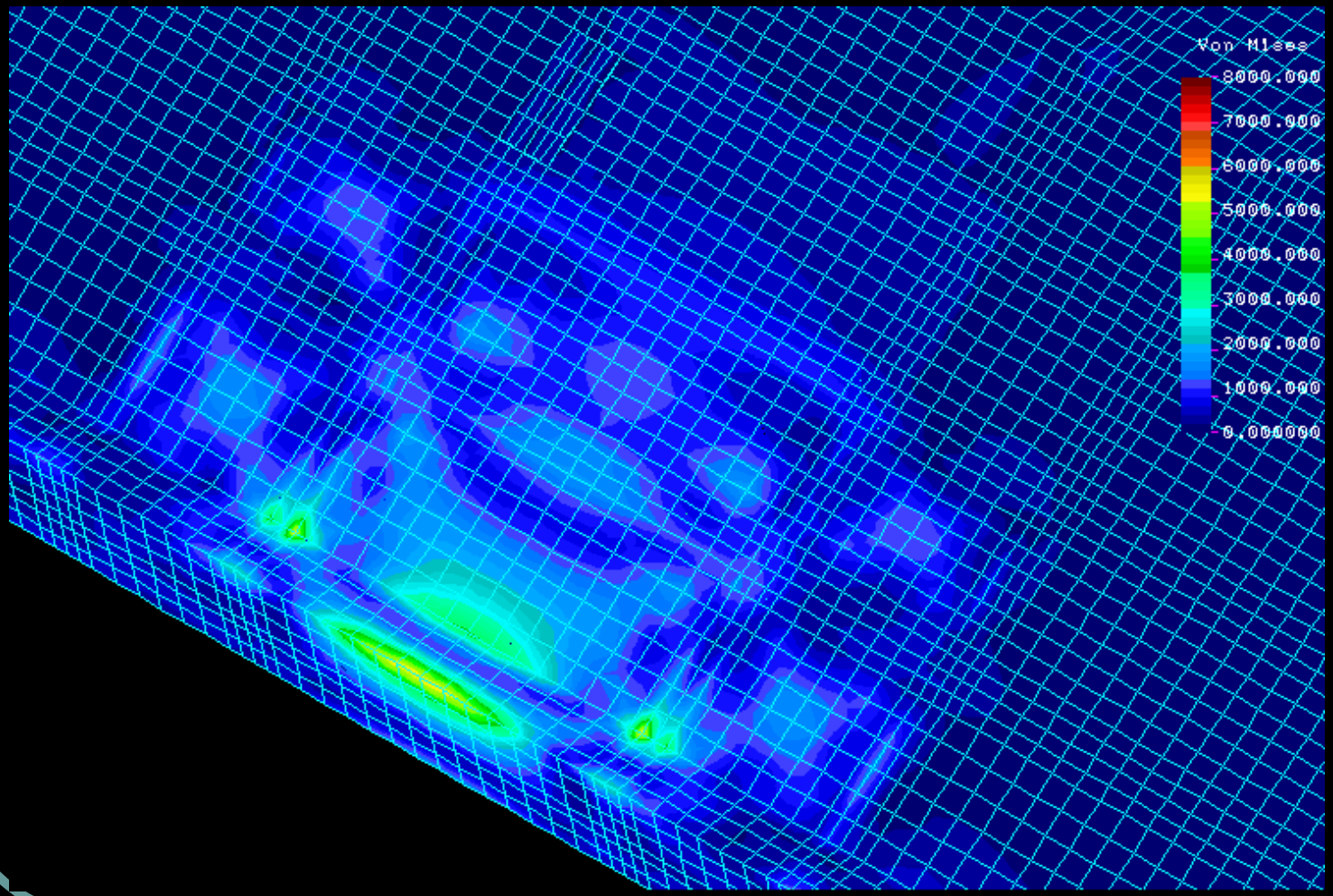
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LC4-FG-Logitudinal Hull Shell Ply Stress



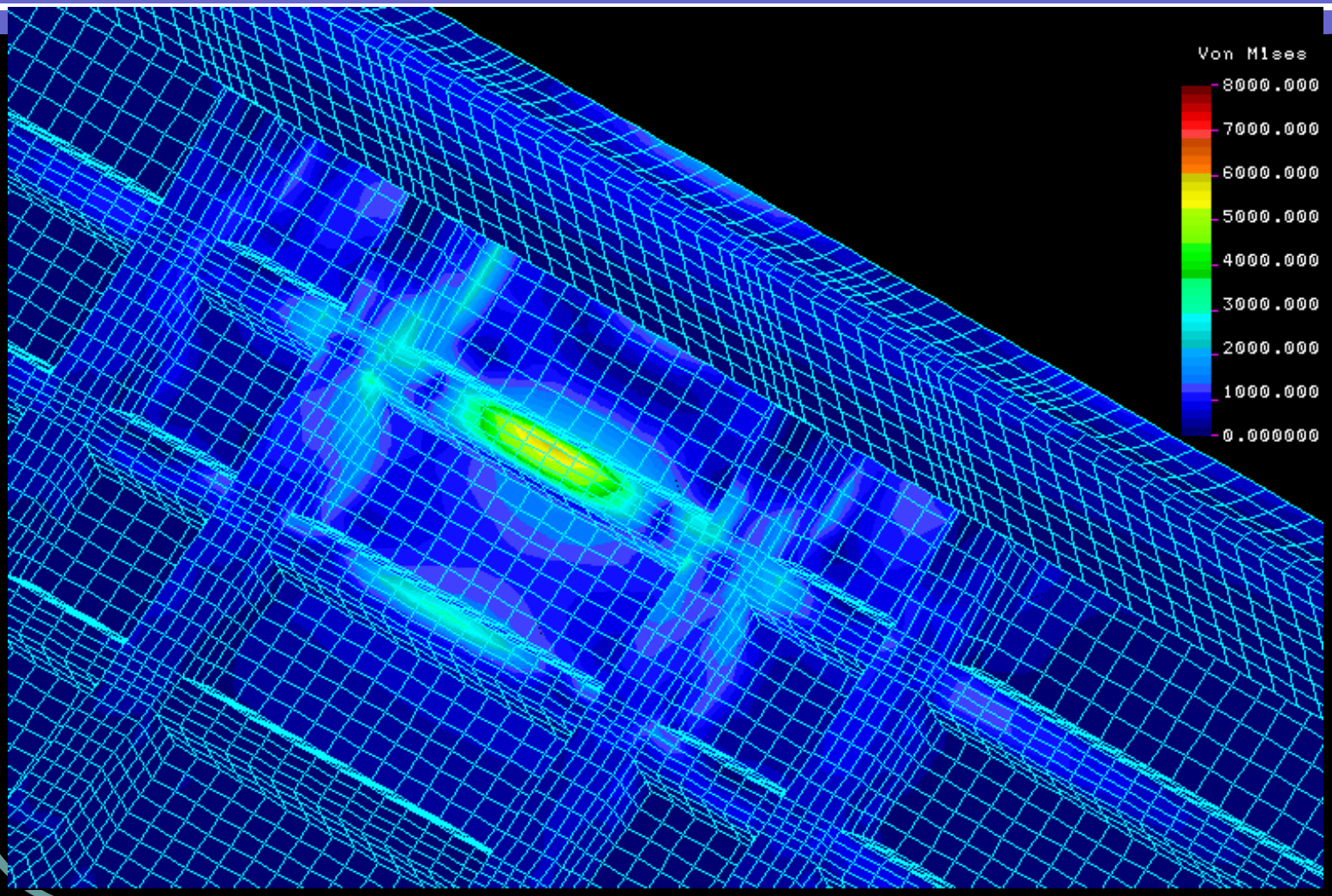
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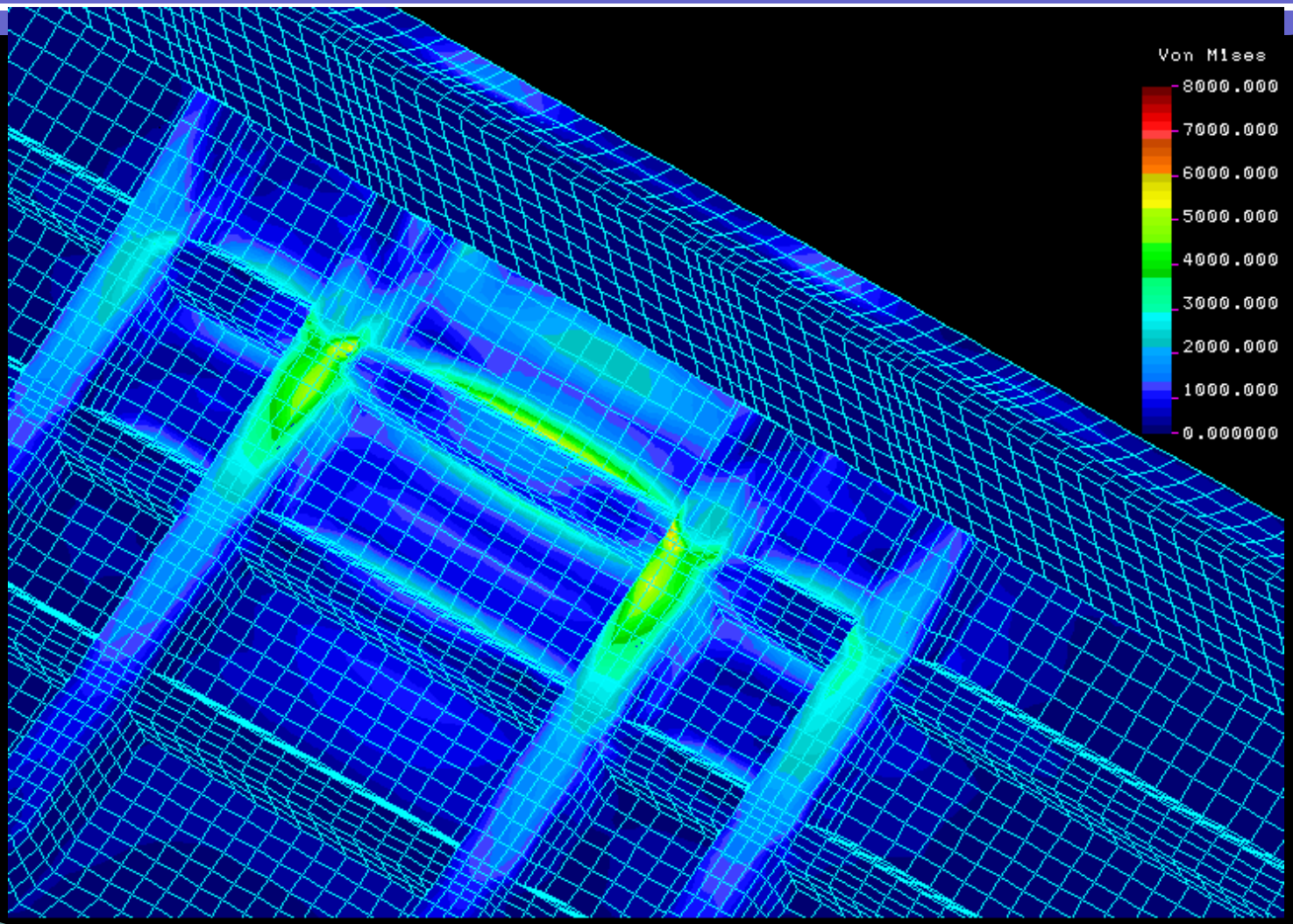
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LC4-FG- Longitudinal Stringer Cap Stress

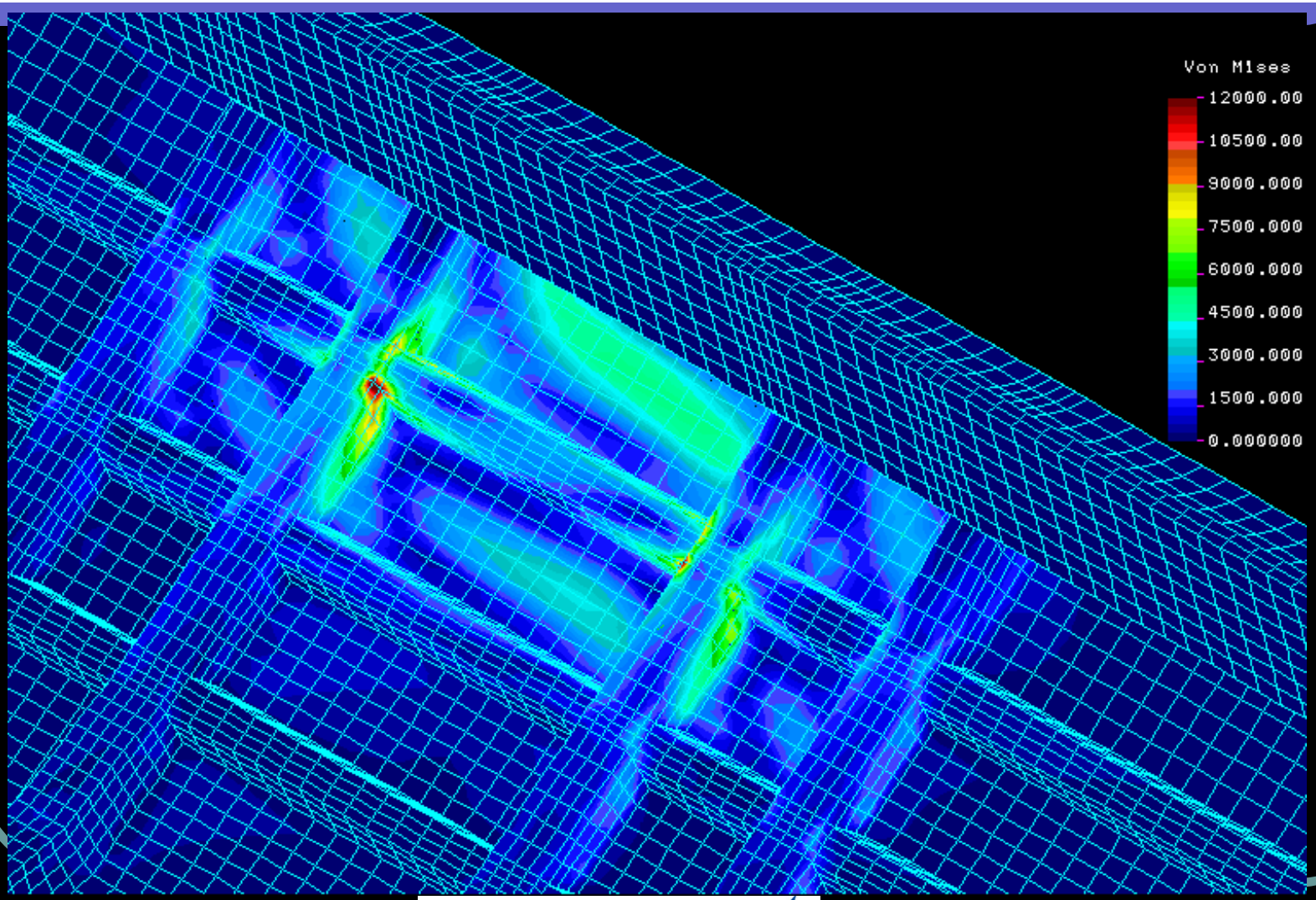


LC4-FG- Transverse Frame Cap Stress



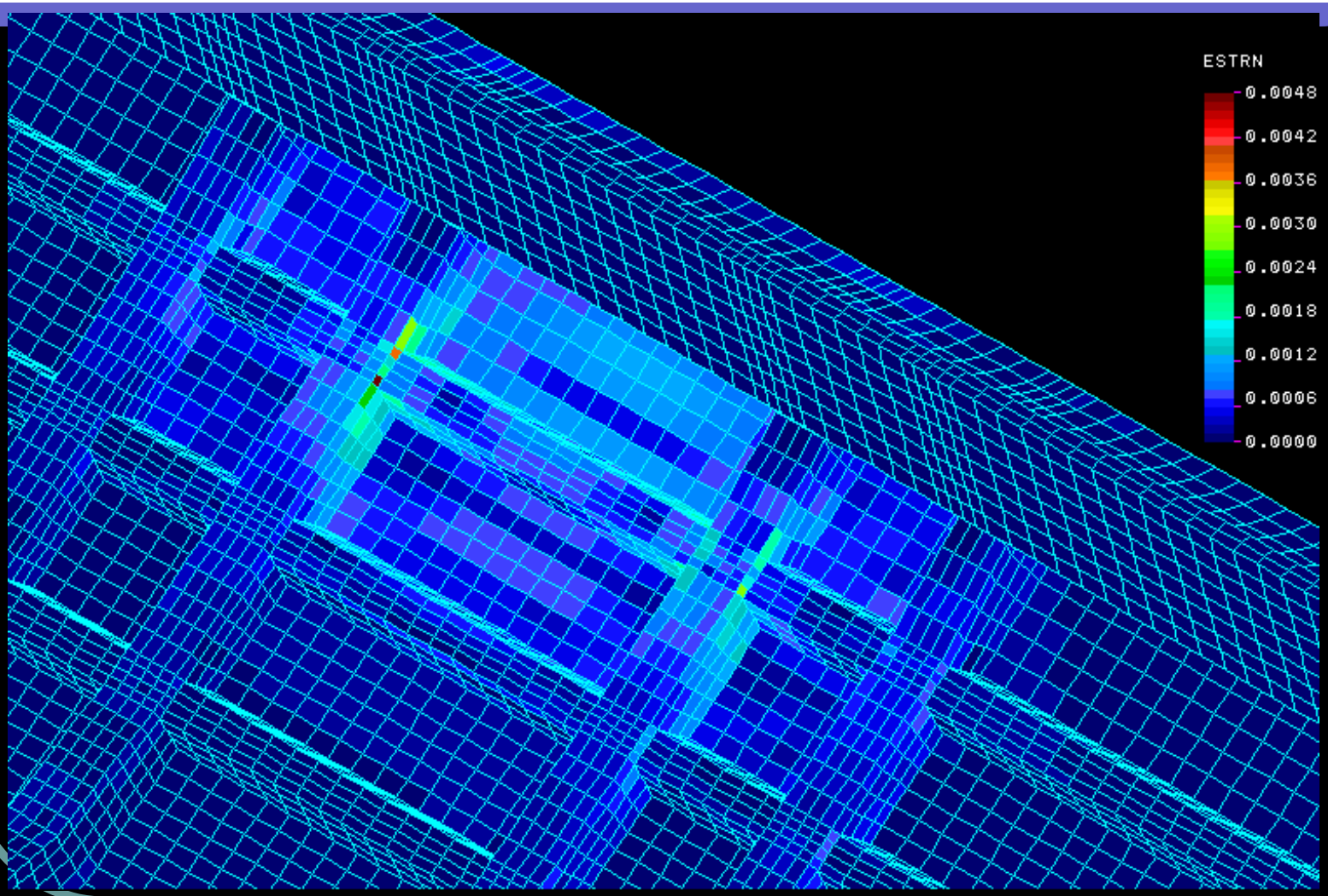
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LC4-FG- 45 Ply Tab and Side Wall Stress

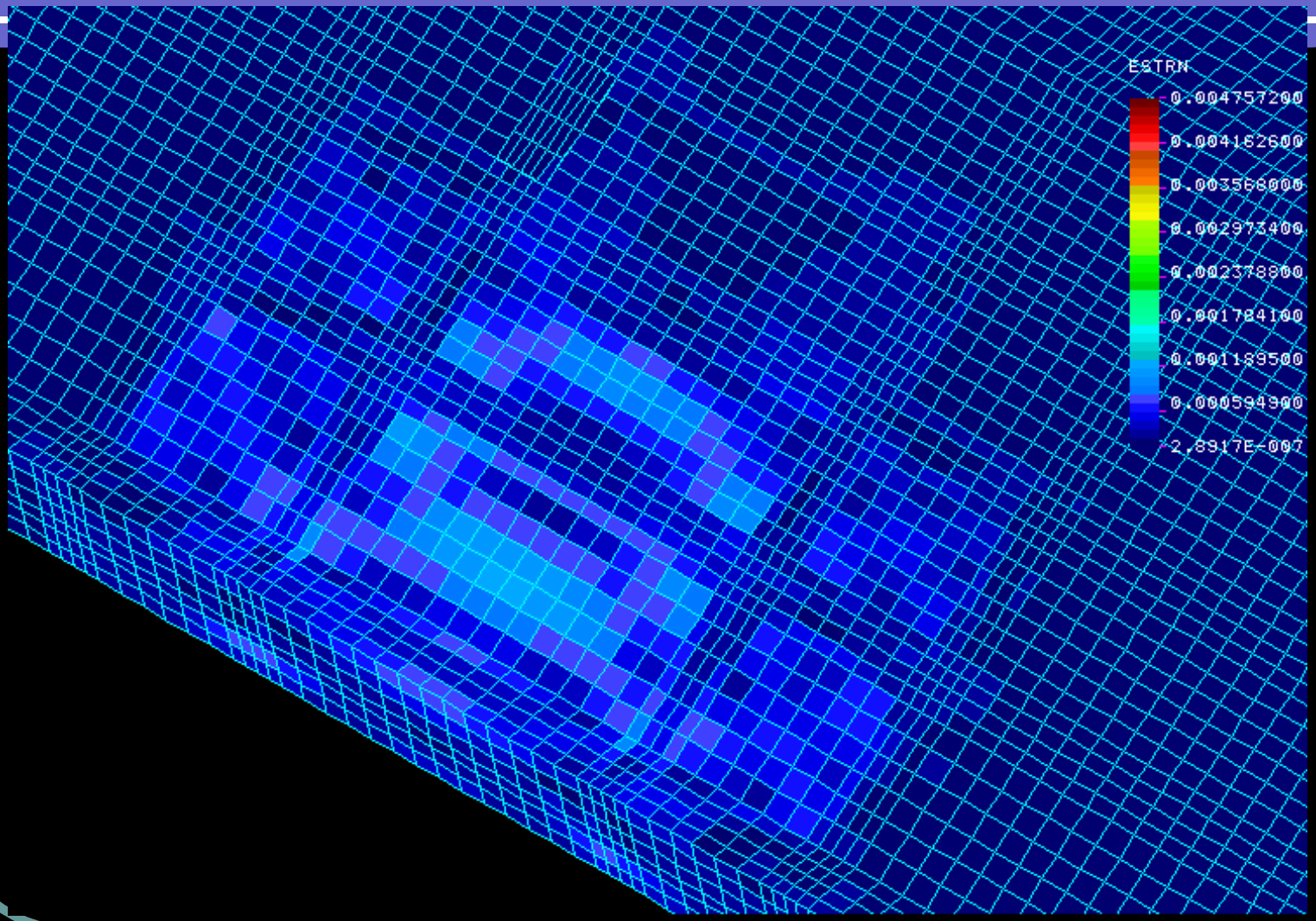


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LC4-FG- Inside Surface Strain



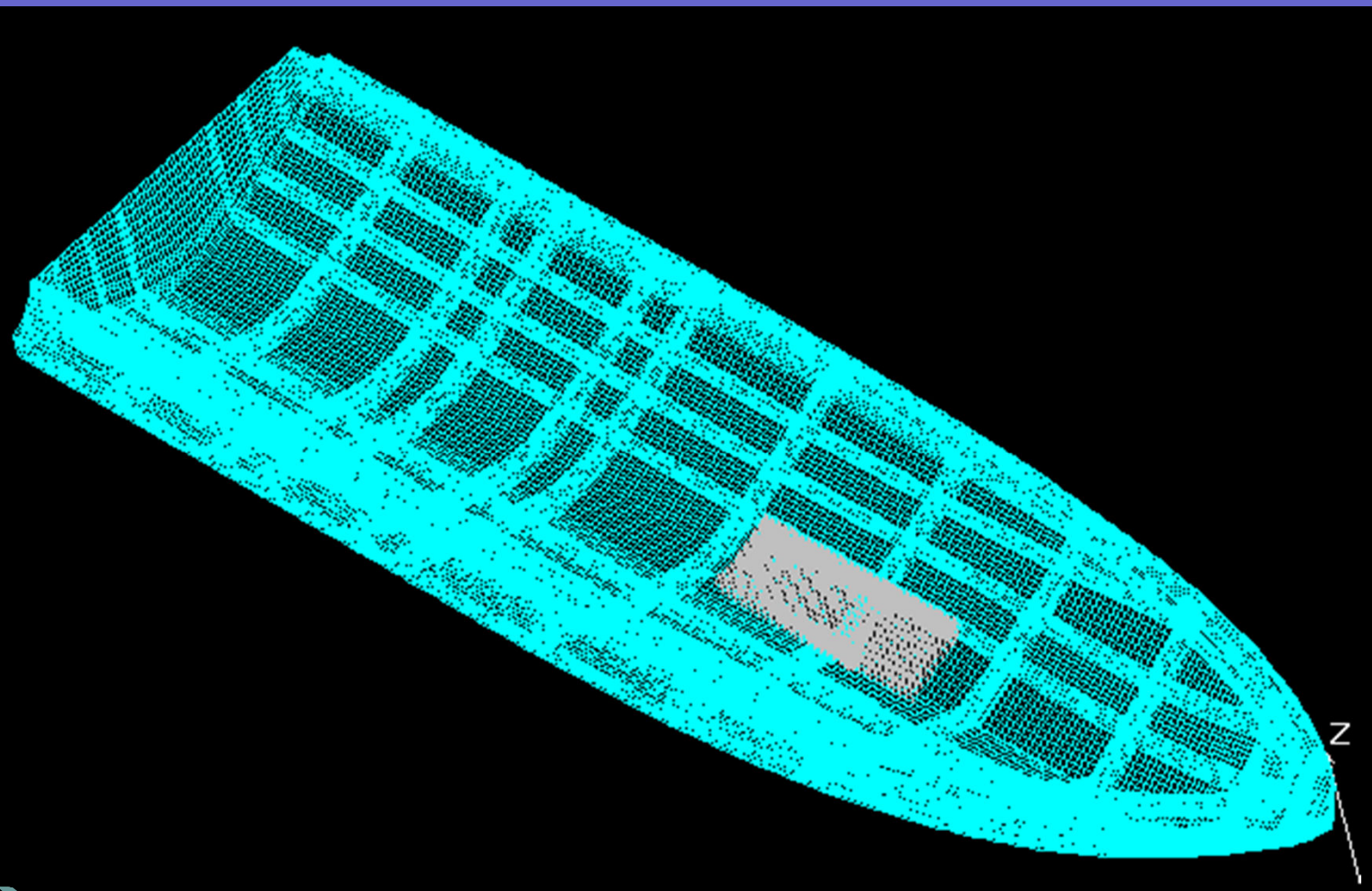
LC4-FG- Outside Surface Strain



LC4-FG- AMO- Summary

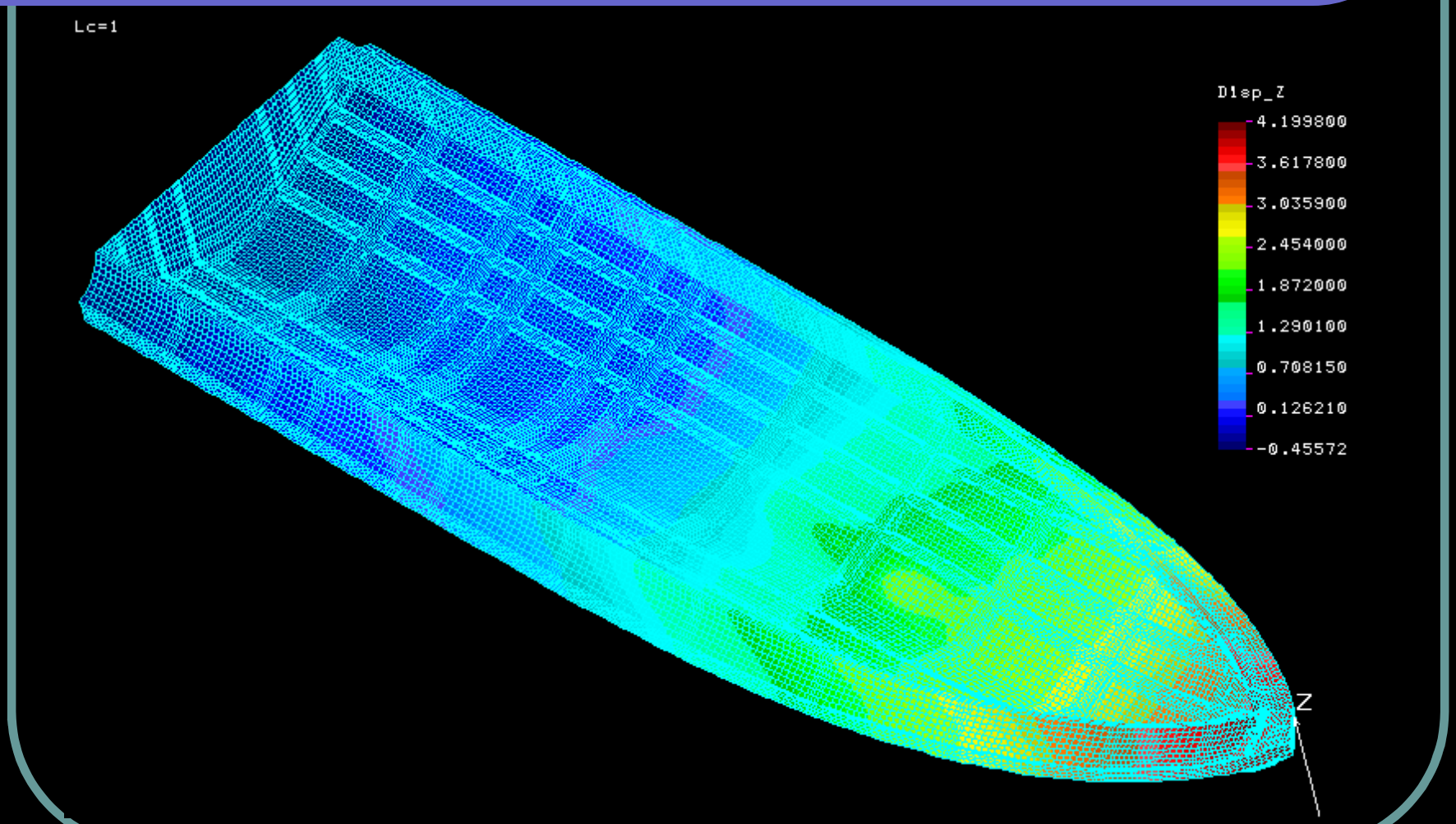
- Hull range of deflection to 0.25 in.
- Maximum Hull strain 0.0012 in/in
- Maximum Hull stress 5,500
- Maximum framing strain 0.003
- Maximum framing stress 12,000 psi

LC5-FG FMI-10 psi Pressure Load



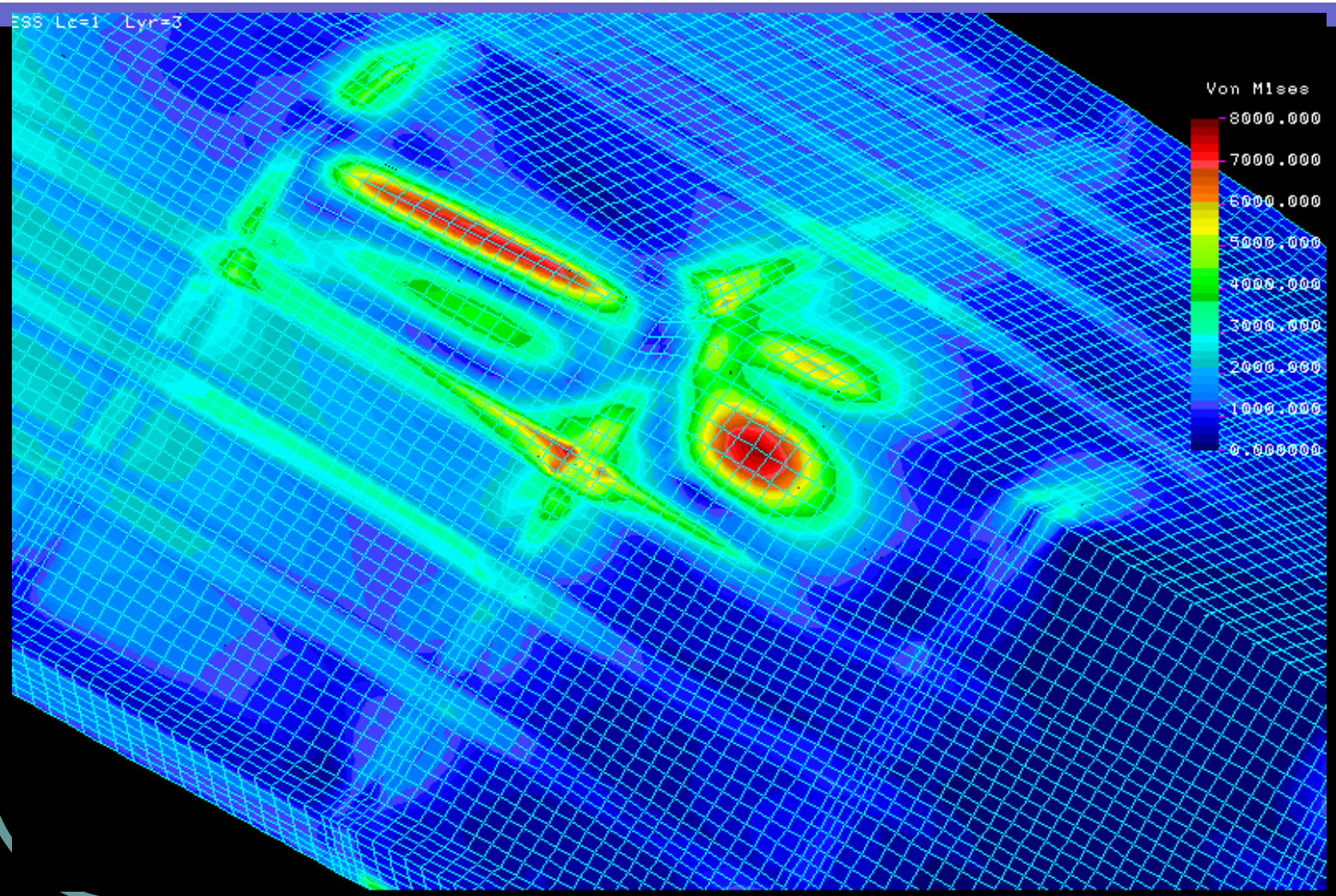
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LC5-FG-Vertical Displacement



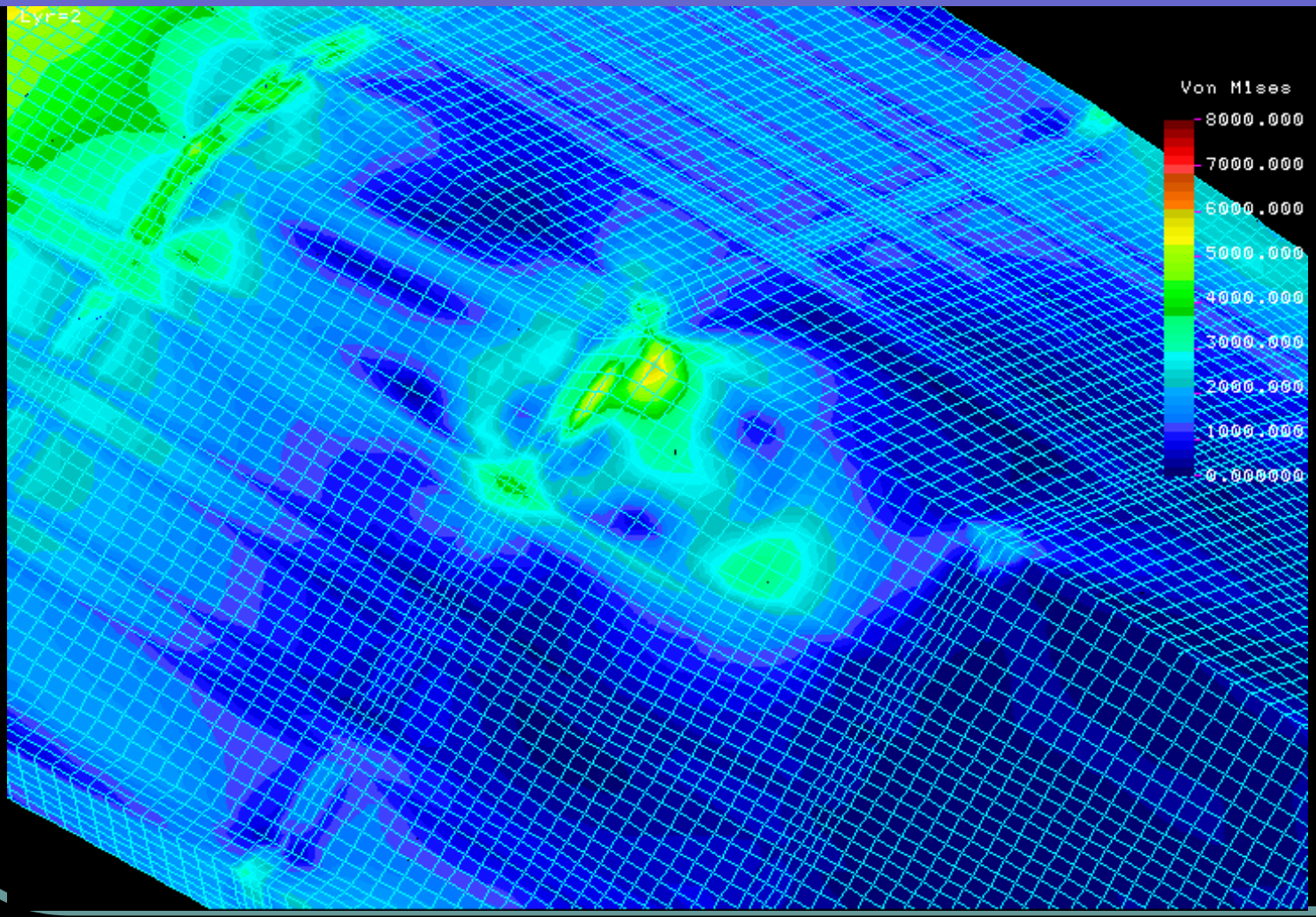
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LC5-FG- Transverse Hull Shell Ply Stress



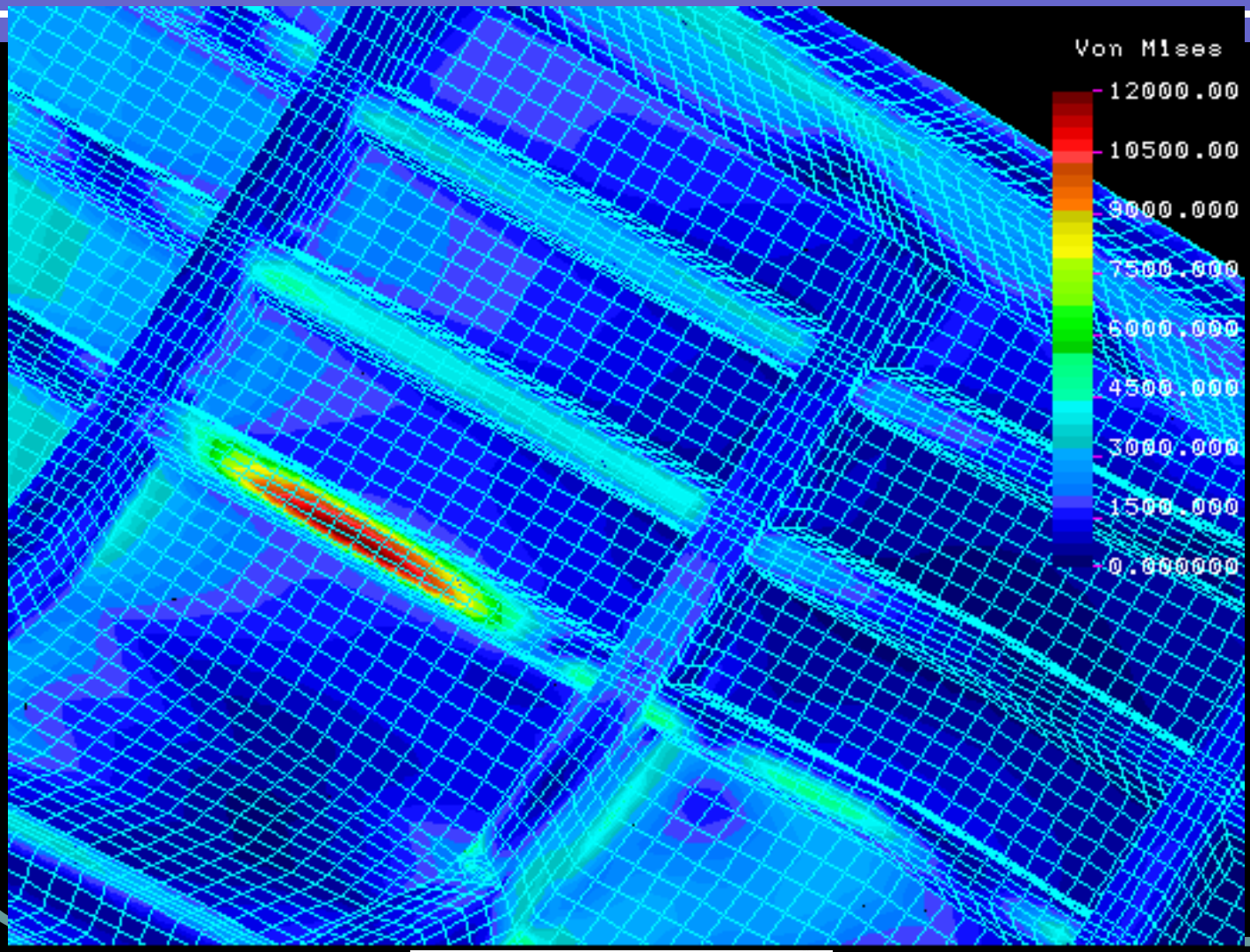
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LC5-FG-Logitudinal Hull Shell Ply Stress

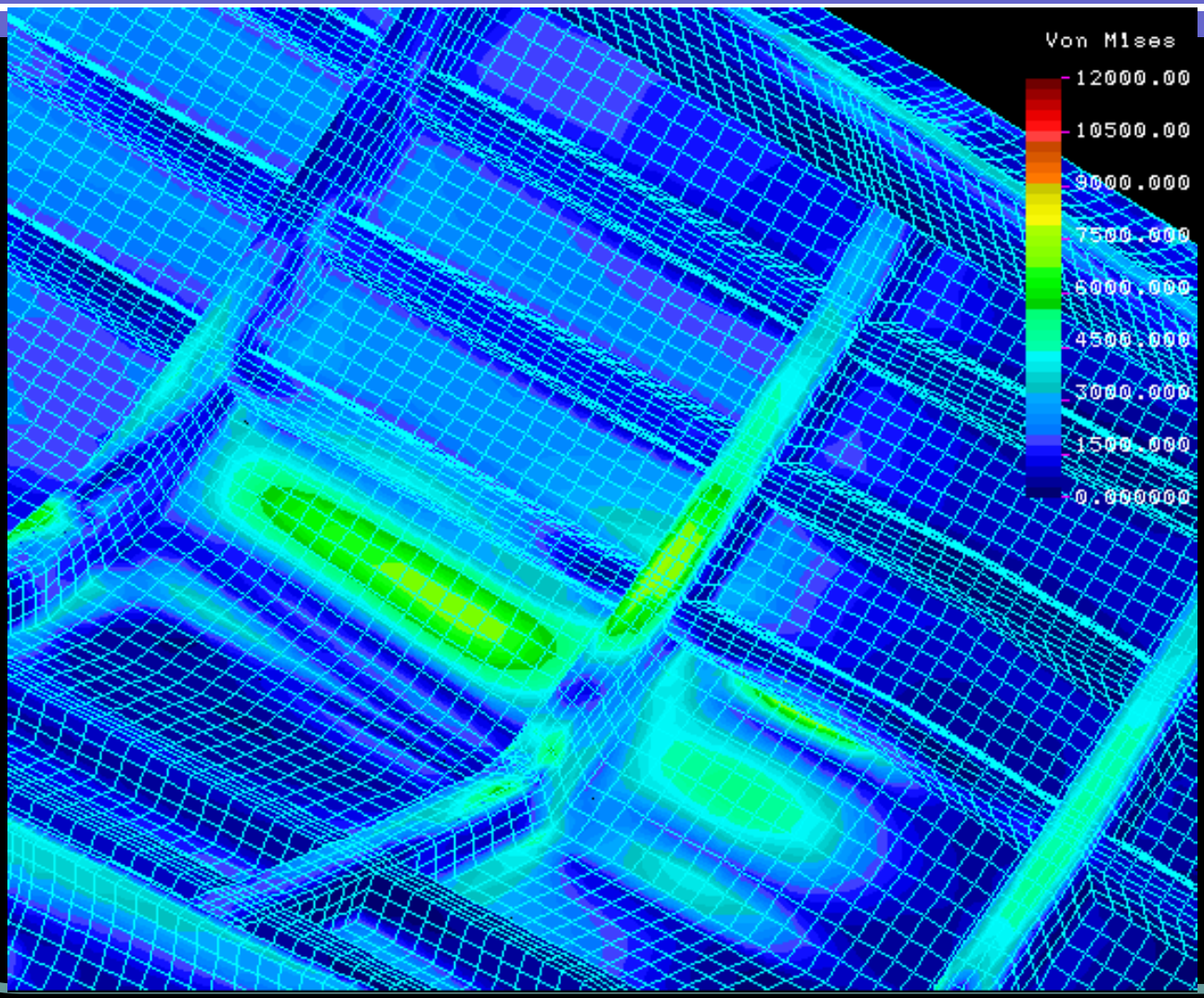


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LC5-FG- Longitudinal Stringer Cap Stress



LC5-FG- Transverse Frame Cap Stress



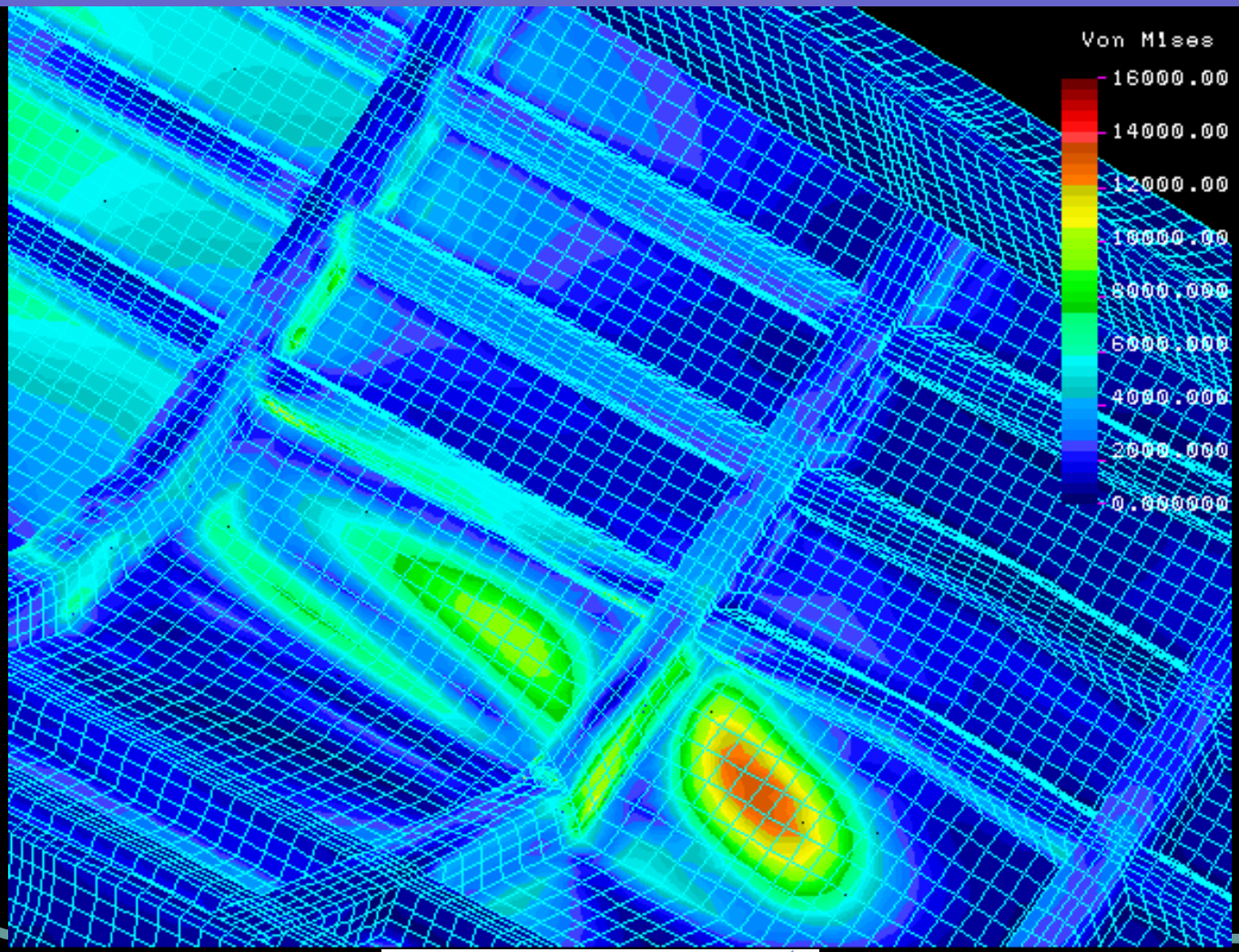
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LC5-FG- 45 Ply Tab and Side Wall Stress



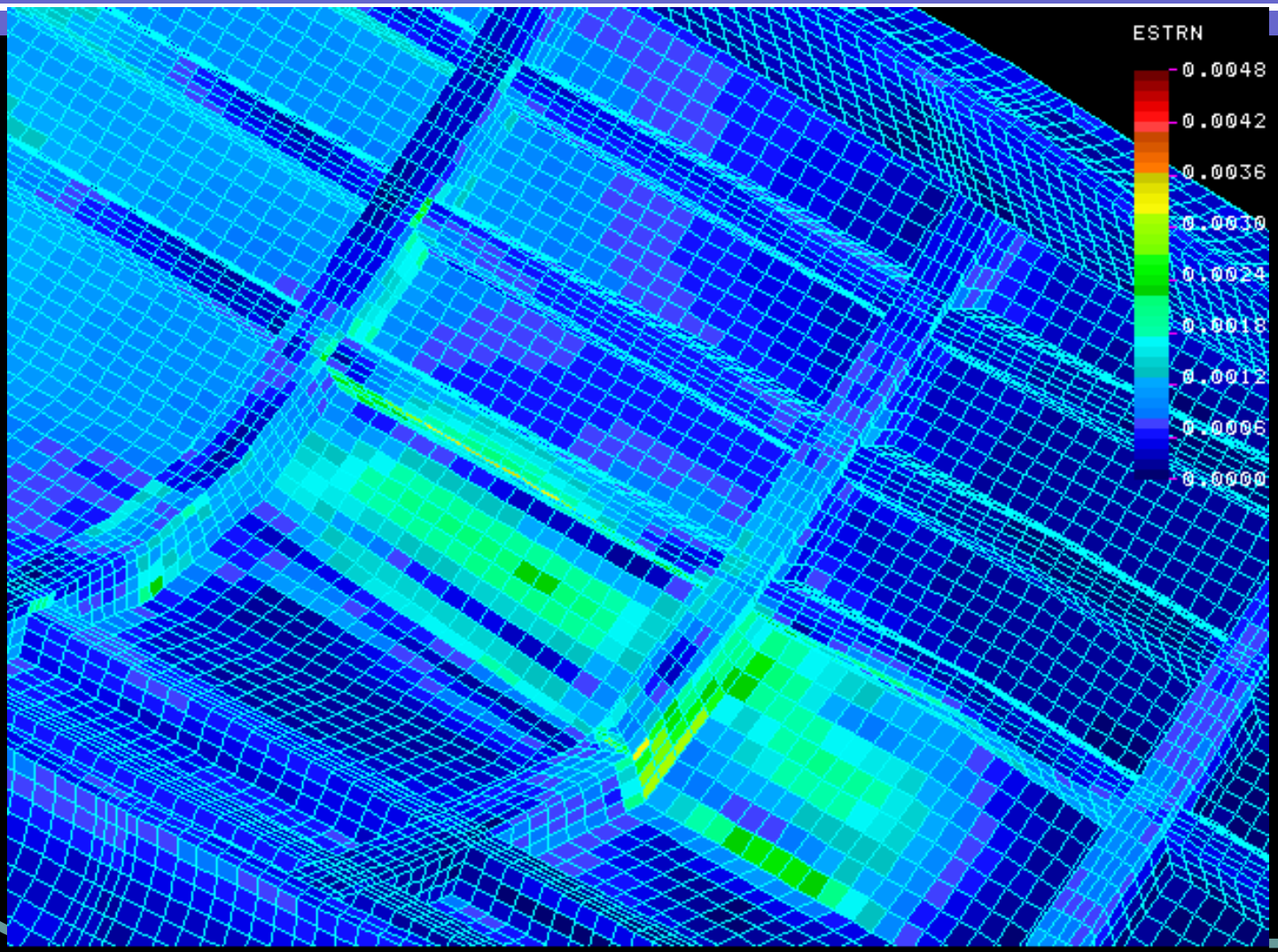
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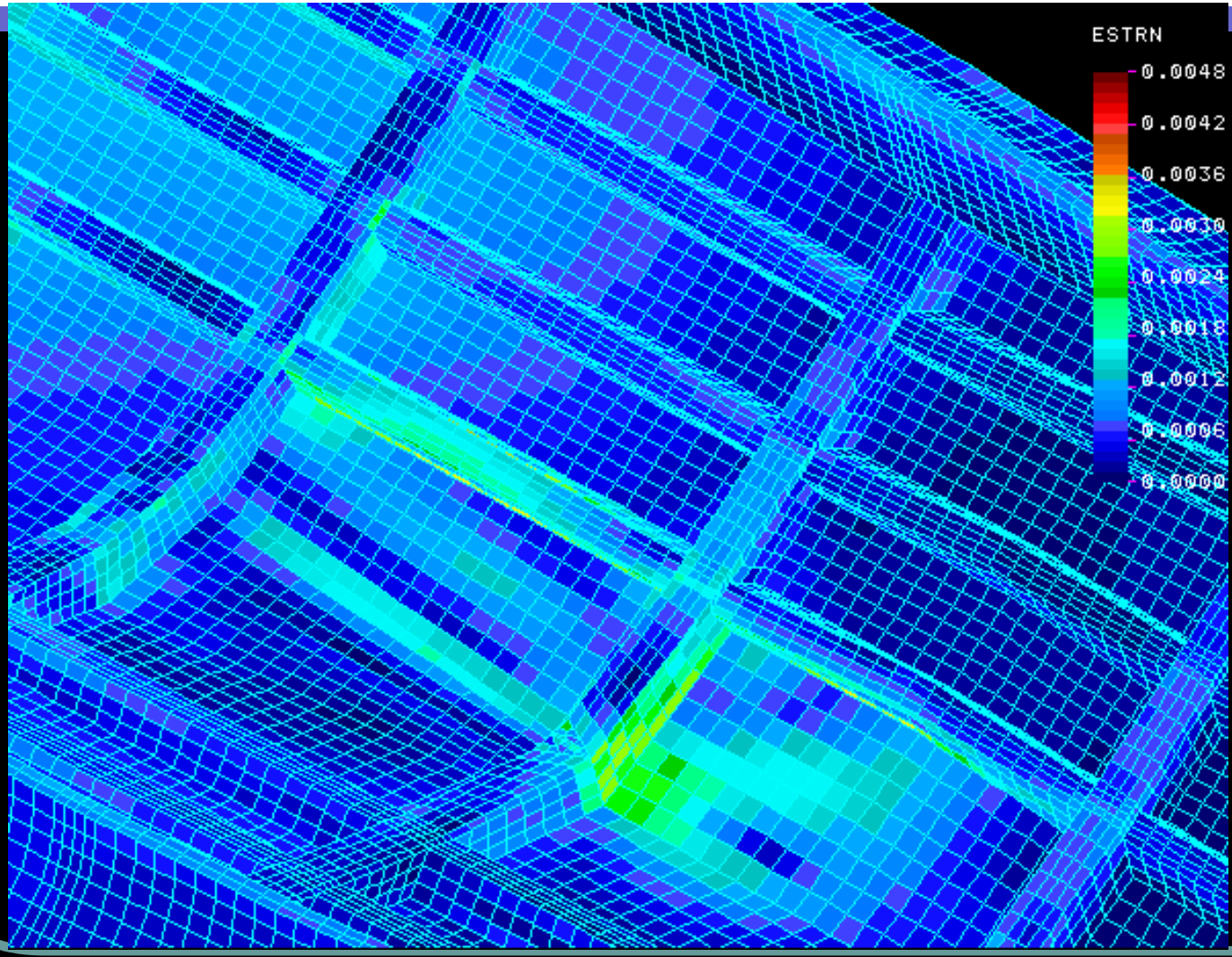
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LC5-FG- Inside Surface Strain



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LC5-FG- Outside Surface Strain

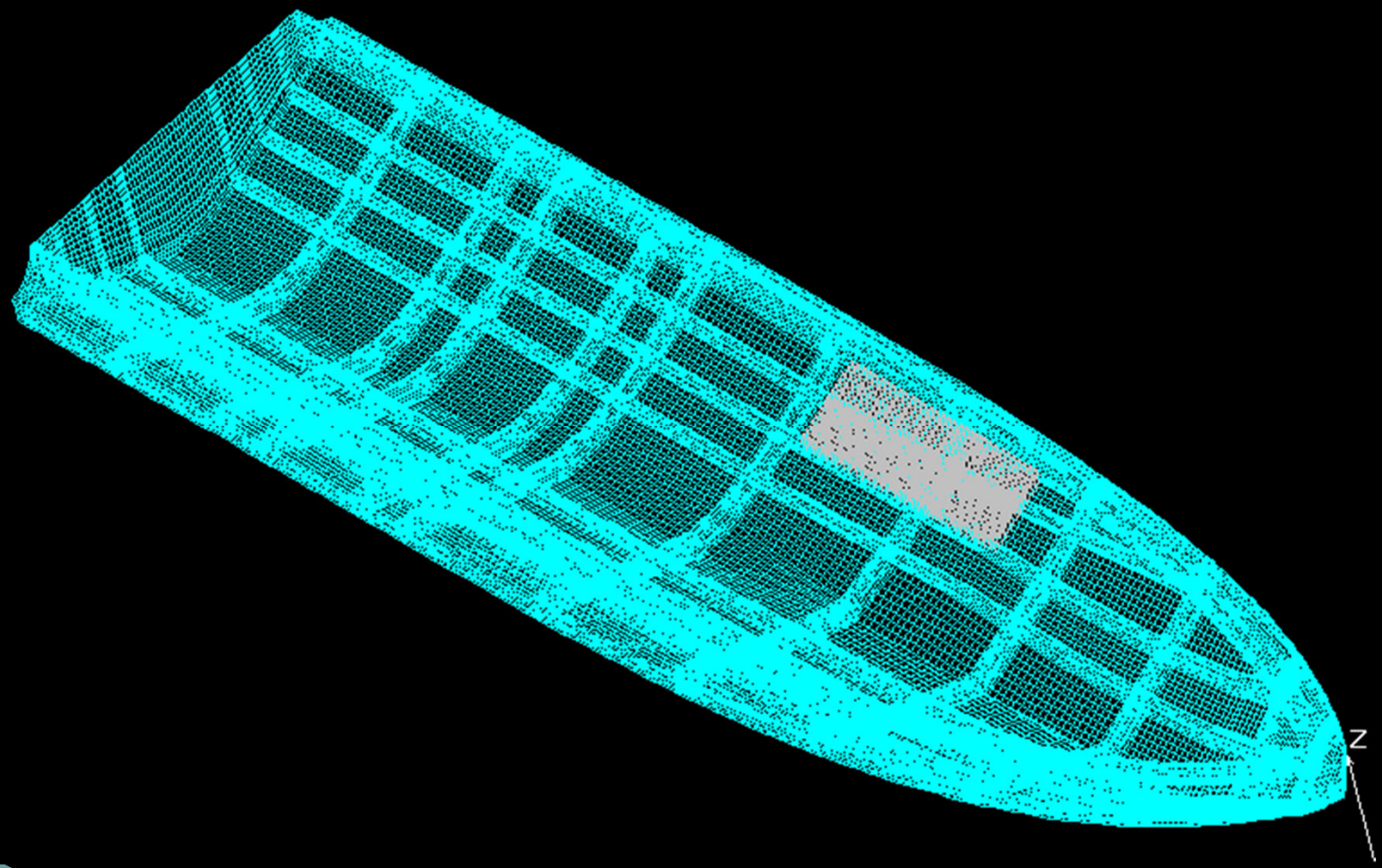


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LC5-FG FMI- Summary

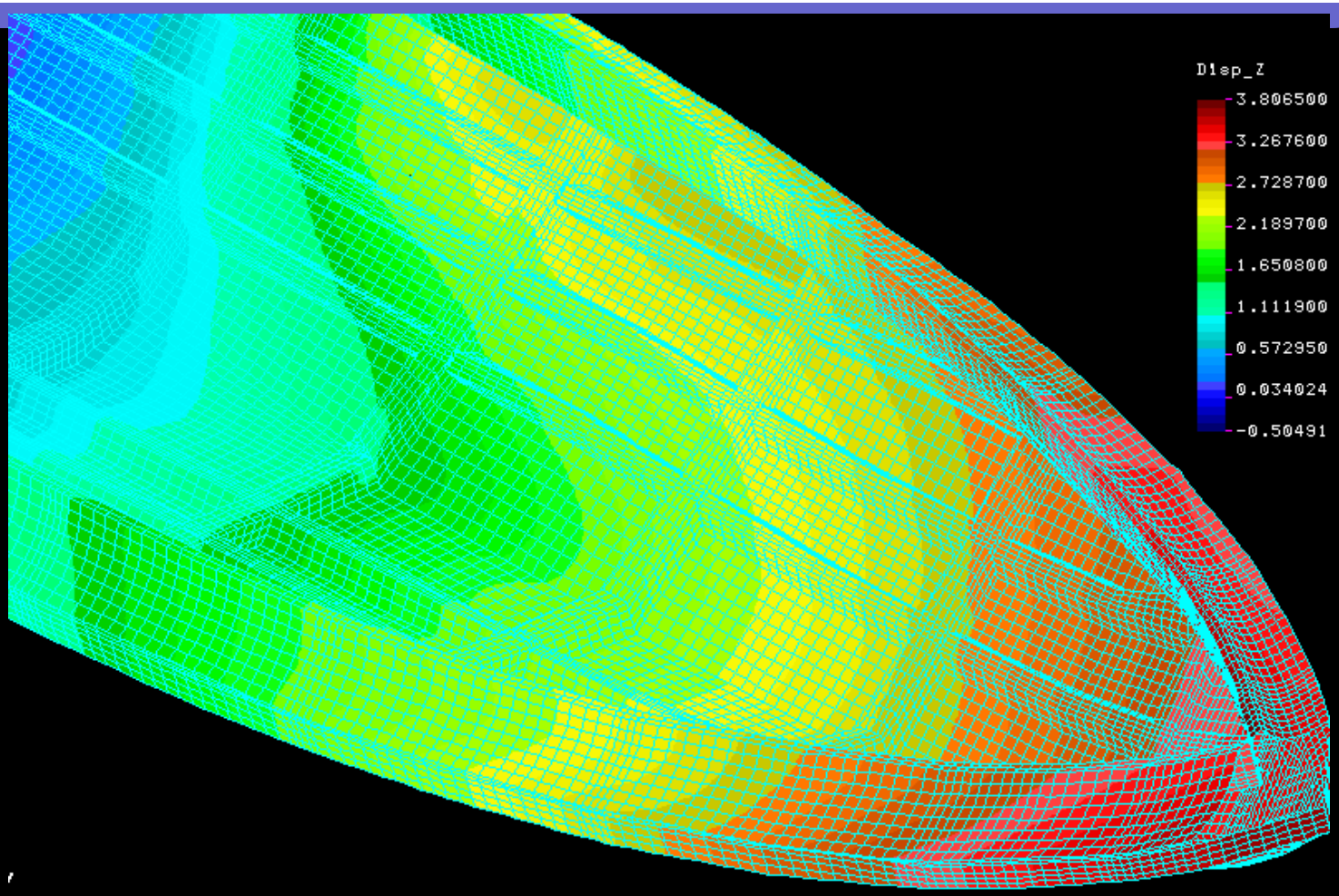
- Hull range of deflection to 4.66 in.
- Maximum Hull strain 0.0027 in/in
- Maximum Hull stress 7,500 psi
- Maximum framing strain 0.0033
- Maximum framing stress 12,000 psi

LC6-FG FMO-10 psi Pressure Load



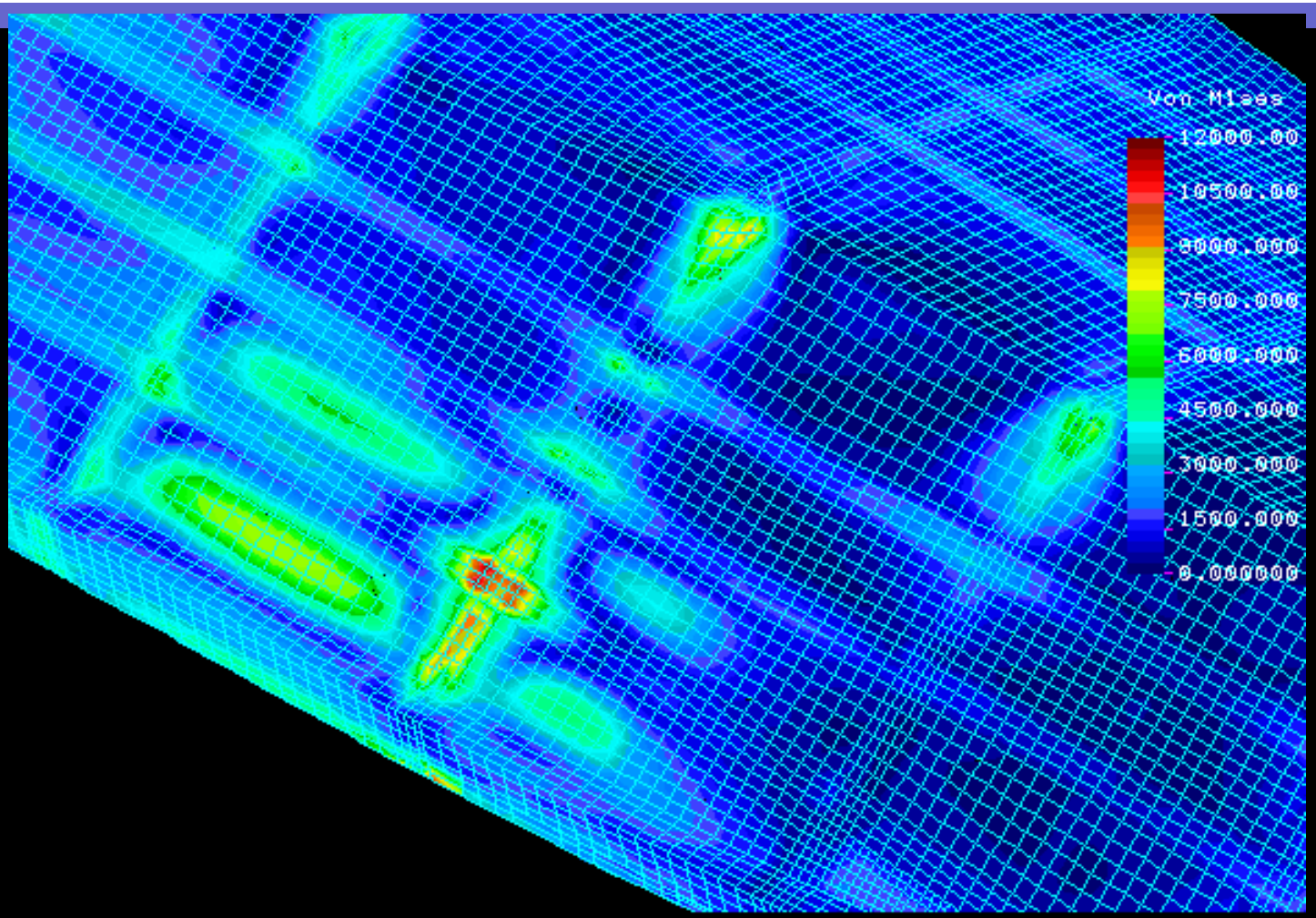
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LC6-FG-Vertical Displacement

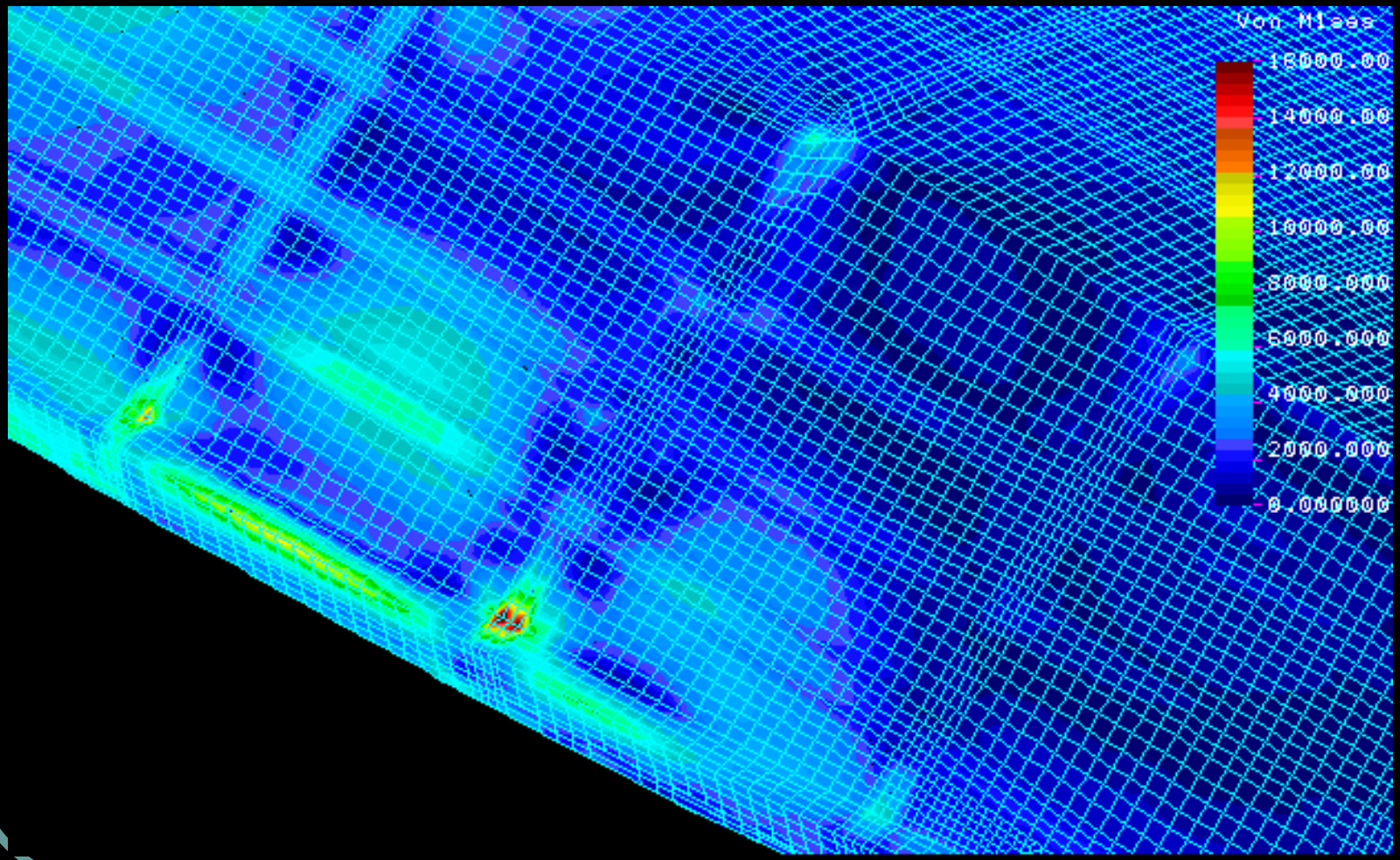


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LC6-FG- Stress Transverse Hull Shell Ply



LC6-FG-Logitudinal Hull Shell Ply Stress



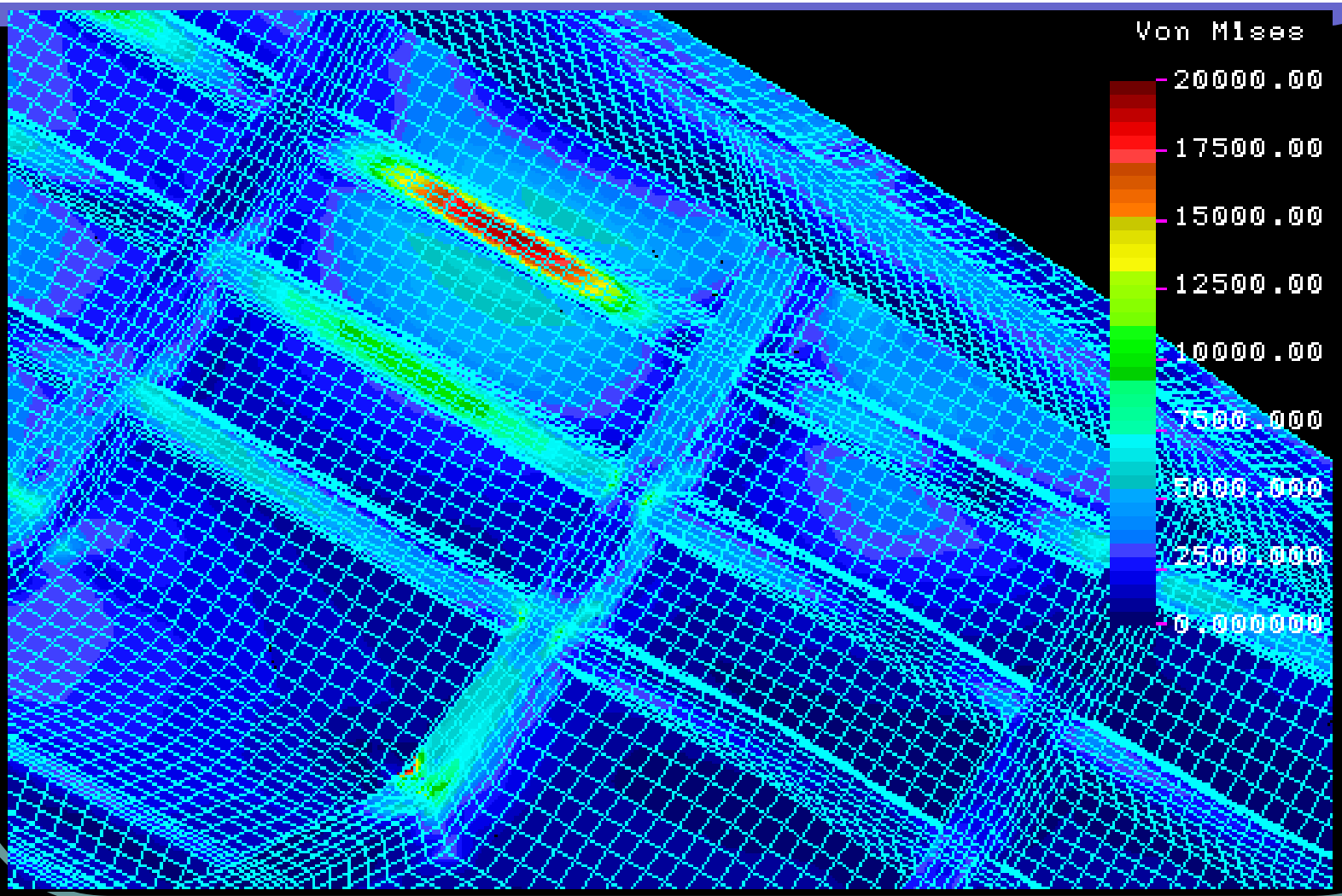
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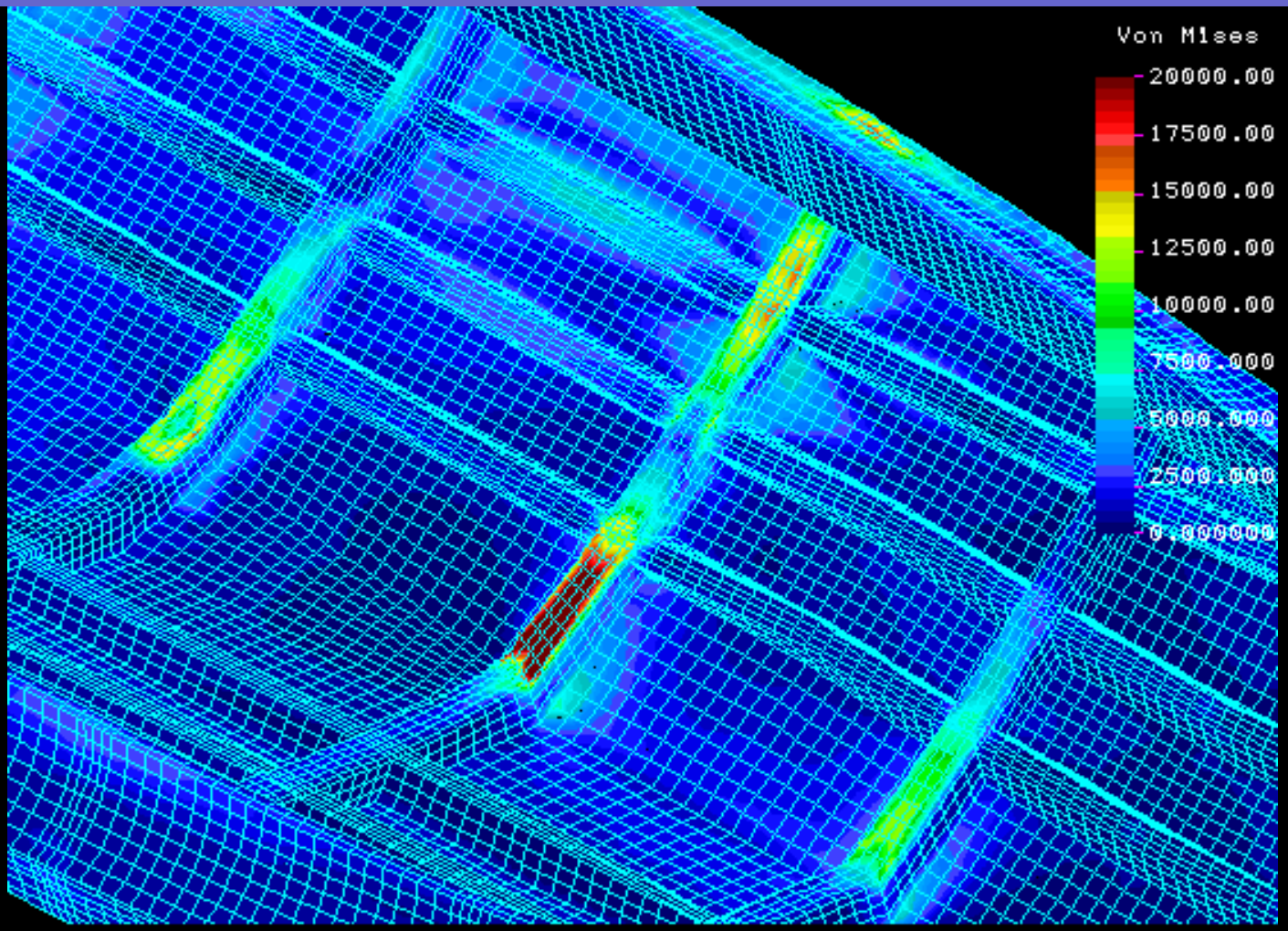
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LC6-FG- Longitudinal Stringer Cap Stress

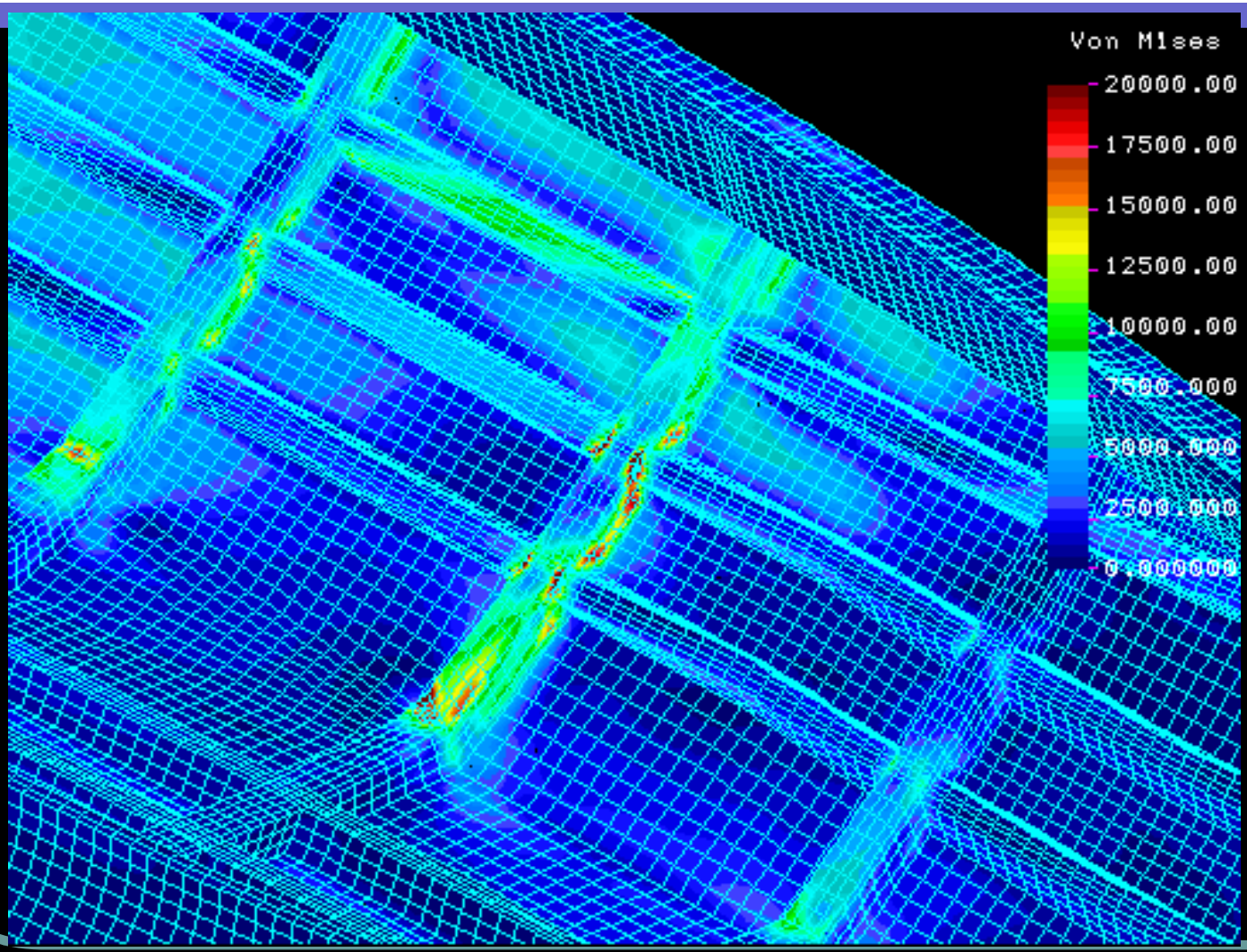


LC6-FG- Transverse Frame Cap Stress



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LC6-FG- 45 Ply Tab and Side Wall Stress



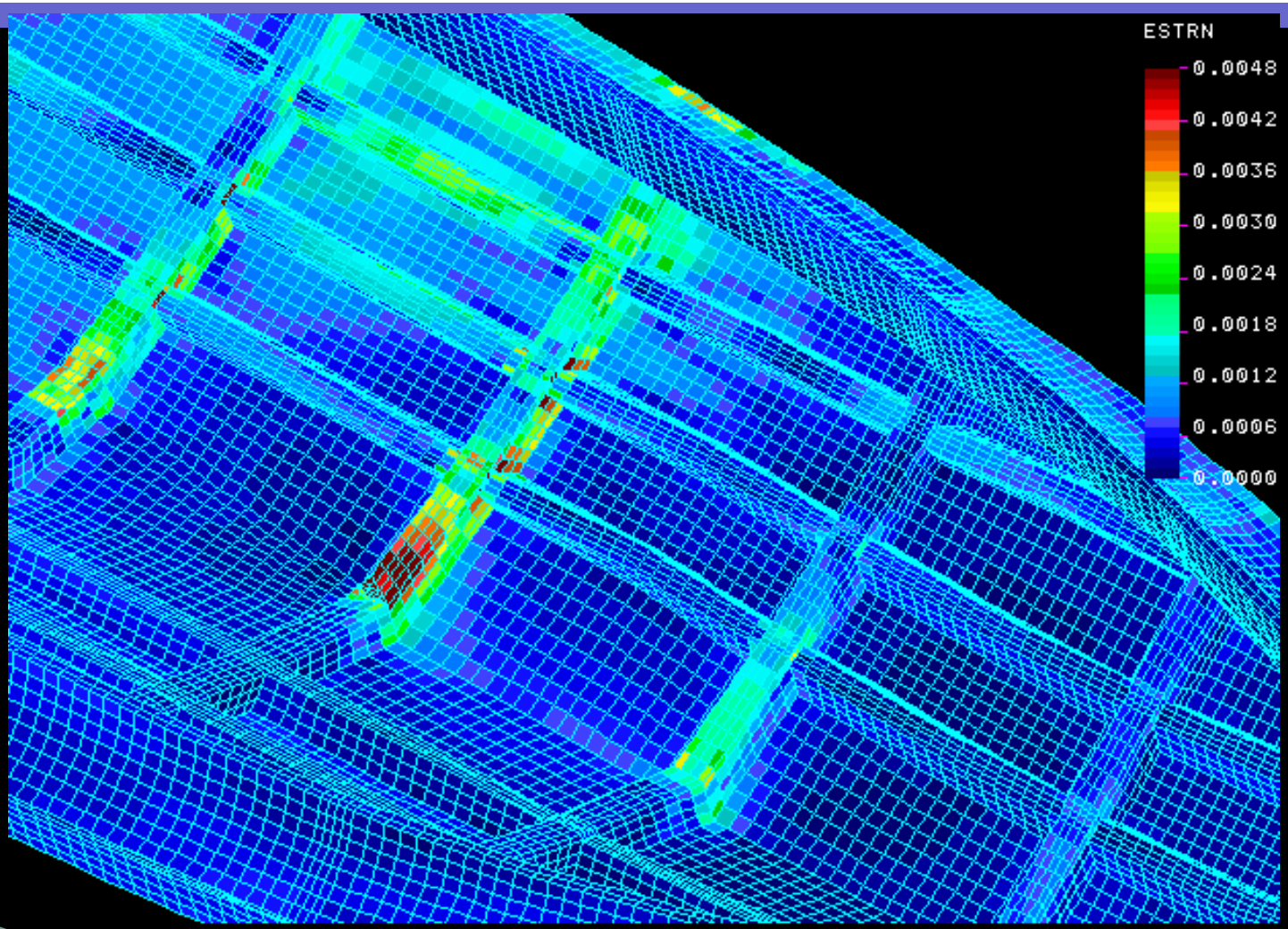
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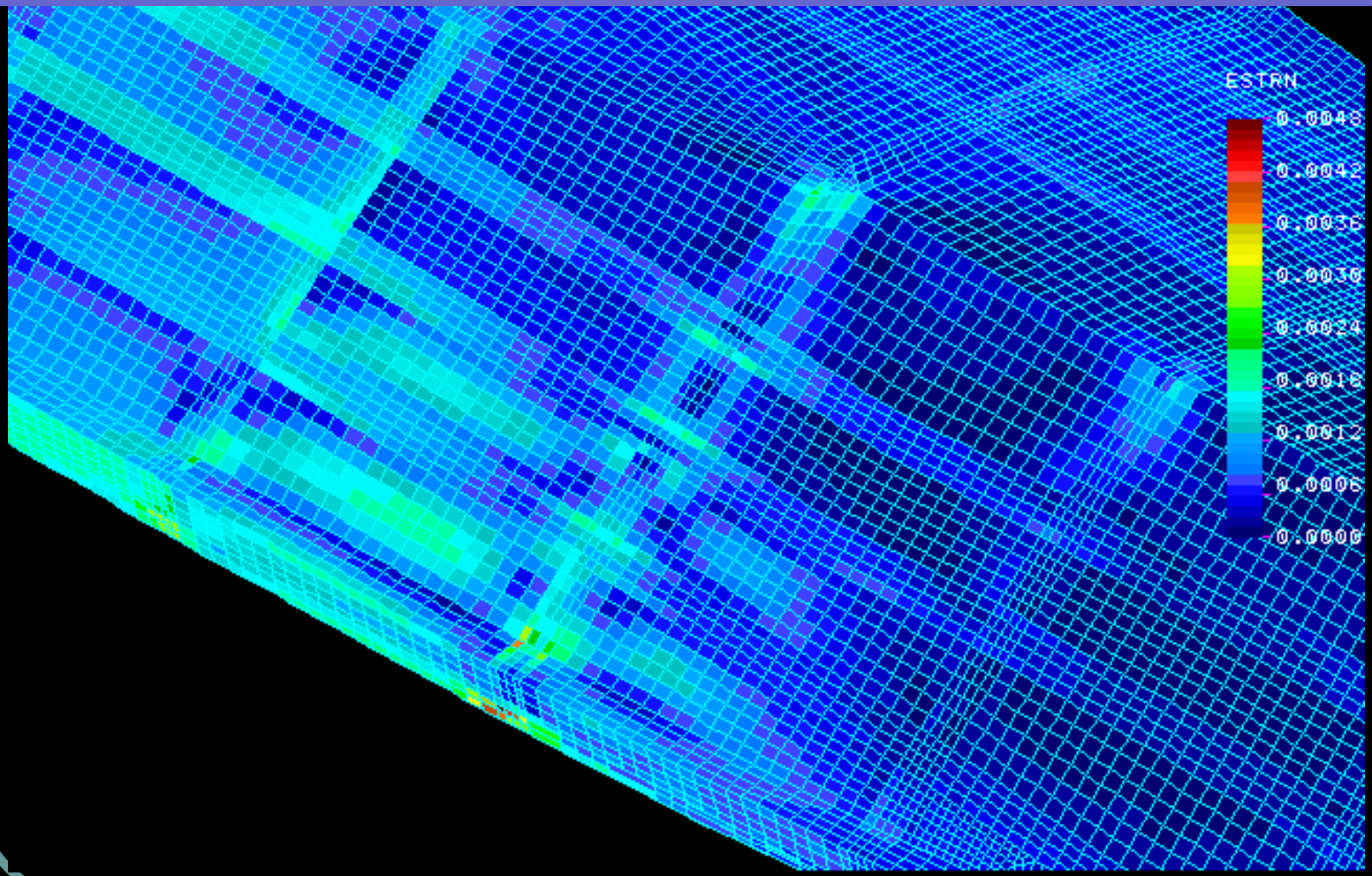
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LC6-FG- Inside Surface Strain



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LC6-FG- Outside Surface Strain



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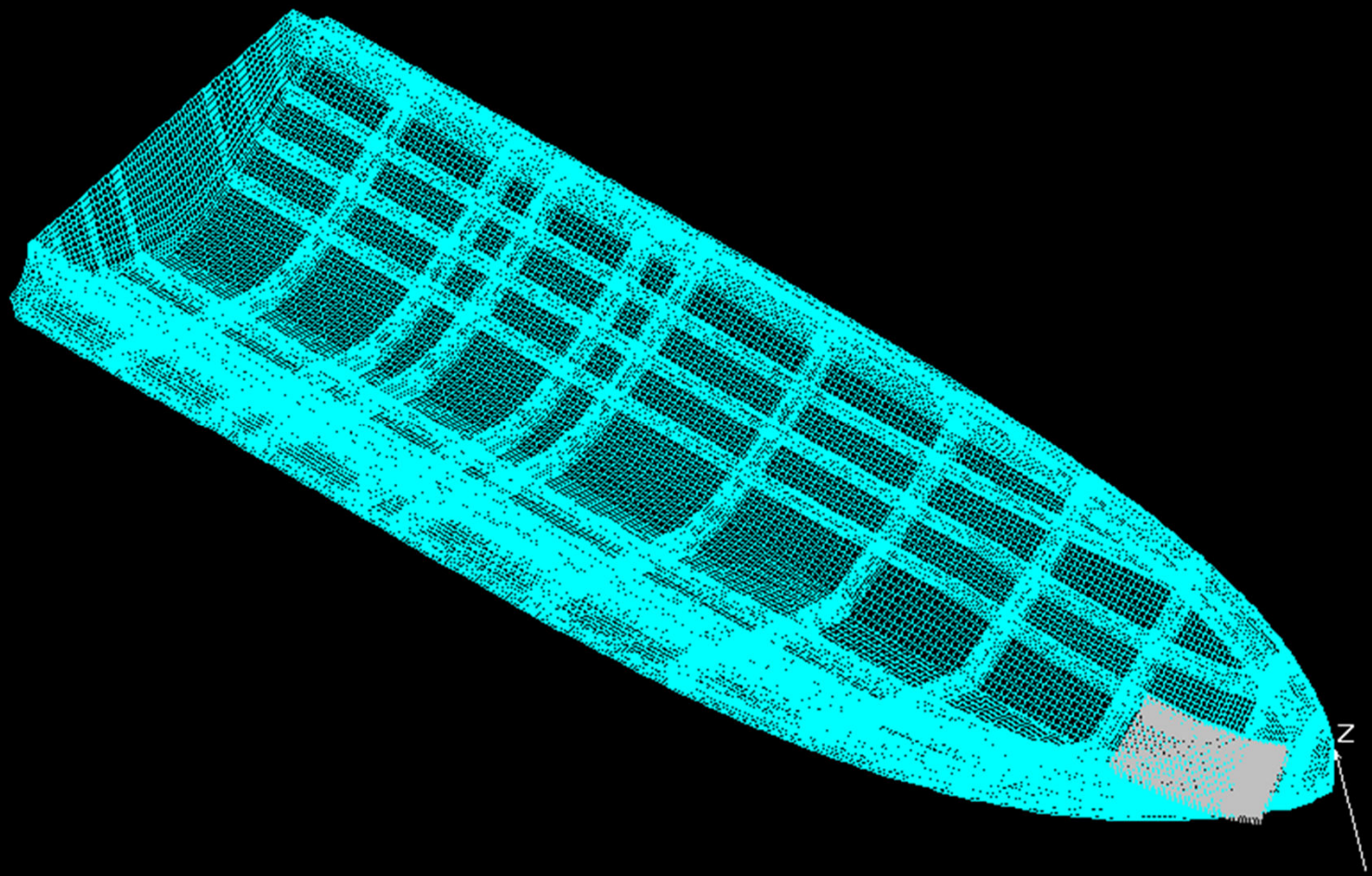
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LC6-FG FMO- Summary

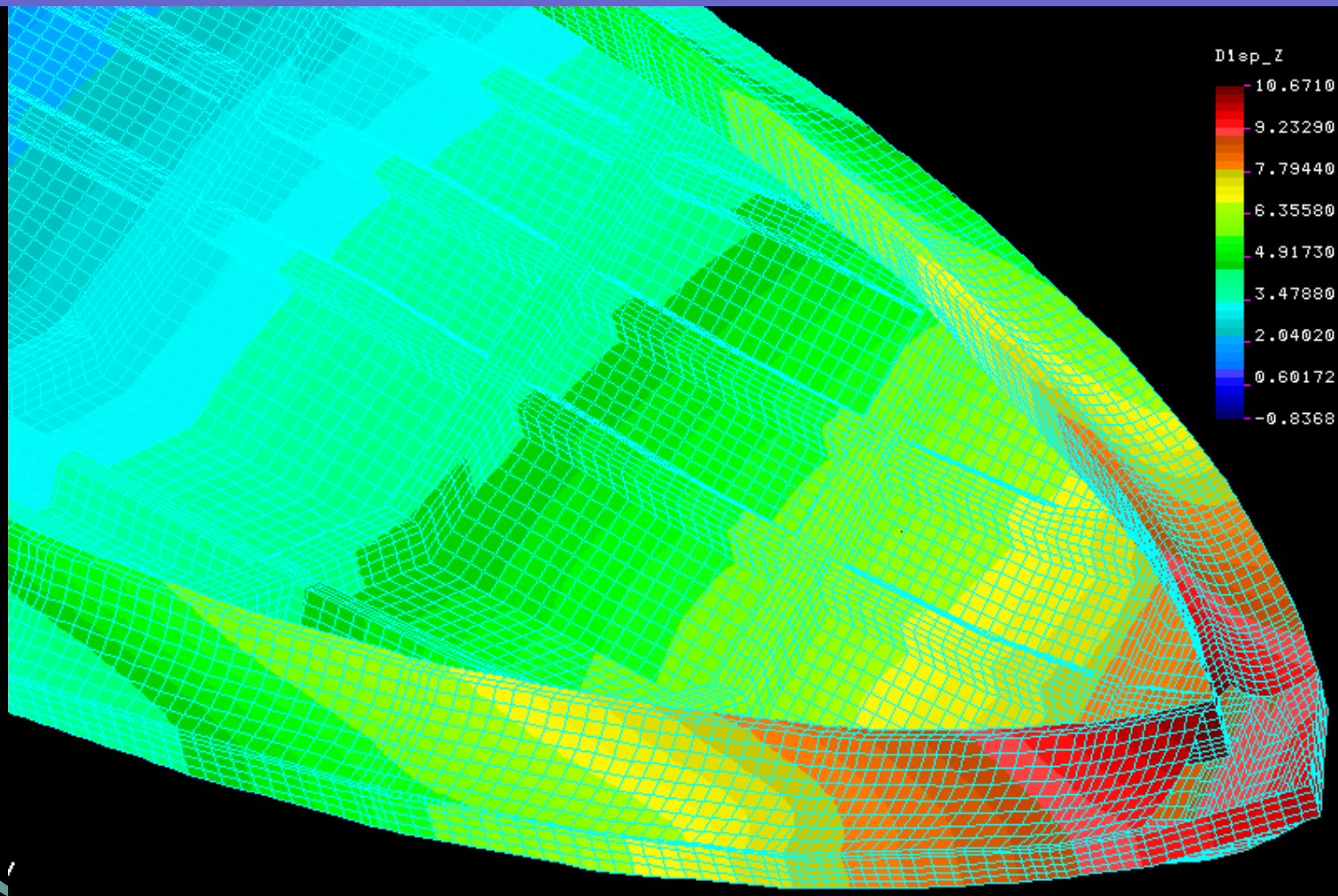
- Hull range of deflection to 4.31 in.
- Maximum Hull strain 0.0033 in/in
- Maximum Hull stress 12,000
- Maximum framing strain 0.0048
- Maximum framing stress 20,000 psi

LC7-FG FI-10 psi Pressure Load



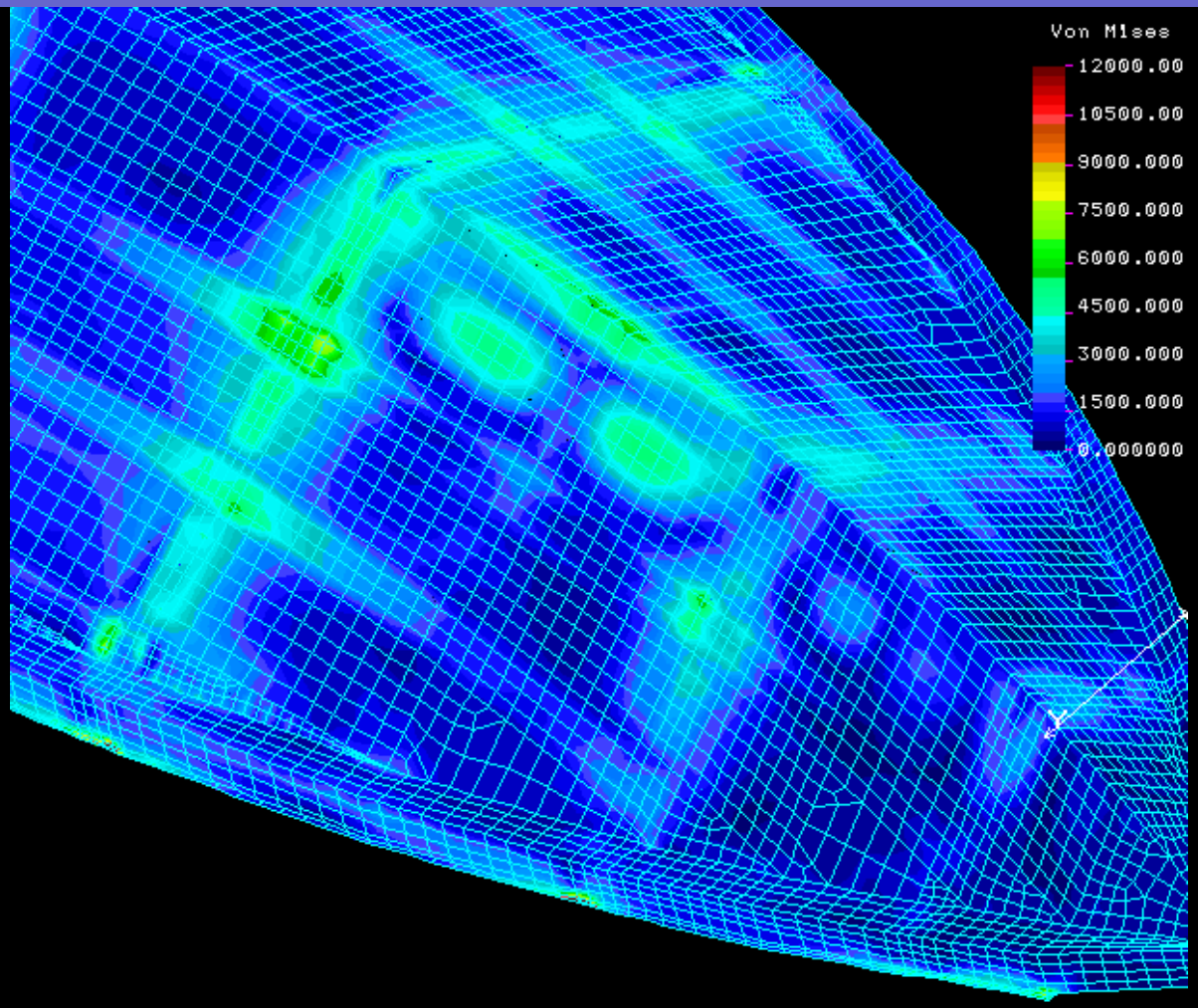
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LC7-FG-Vertical Displacement

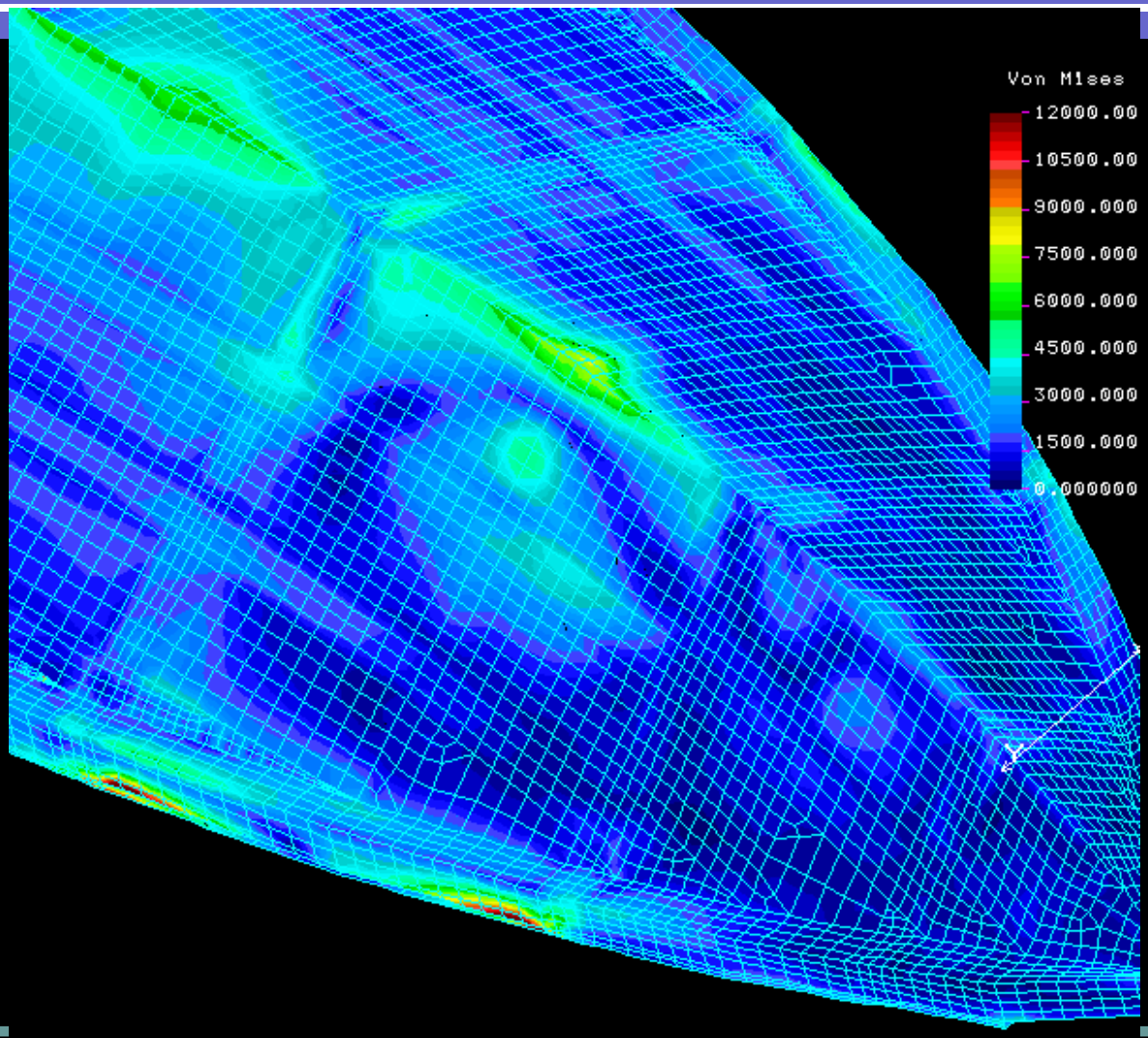


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LC7-FG- Stress Transverse Hull Shell Ply

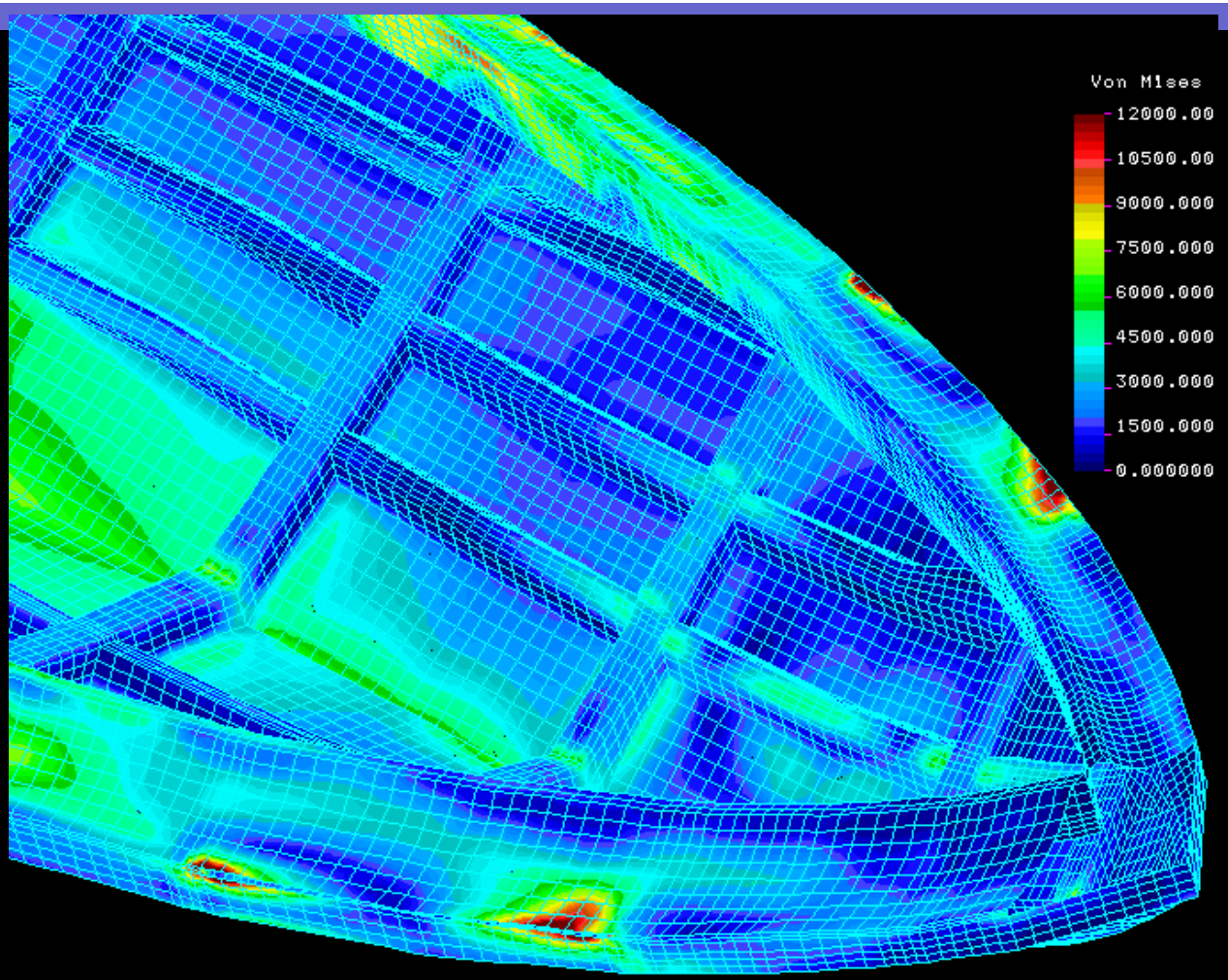


LC7-FG-Logitudinal Hull Shell Ply Stress

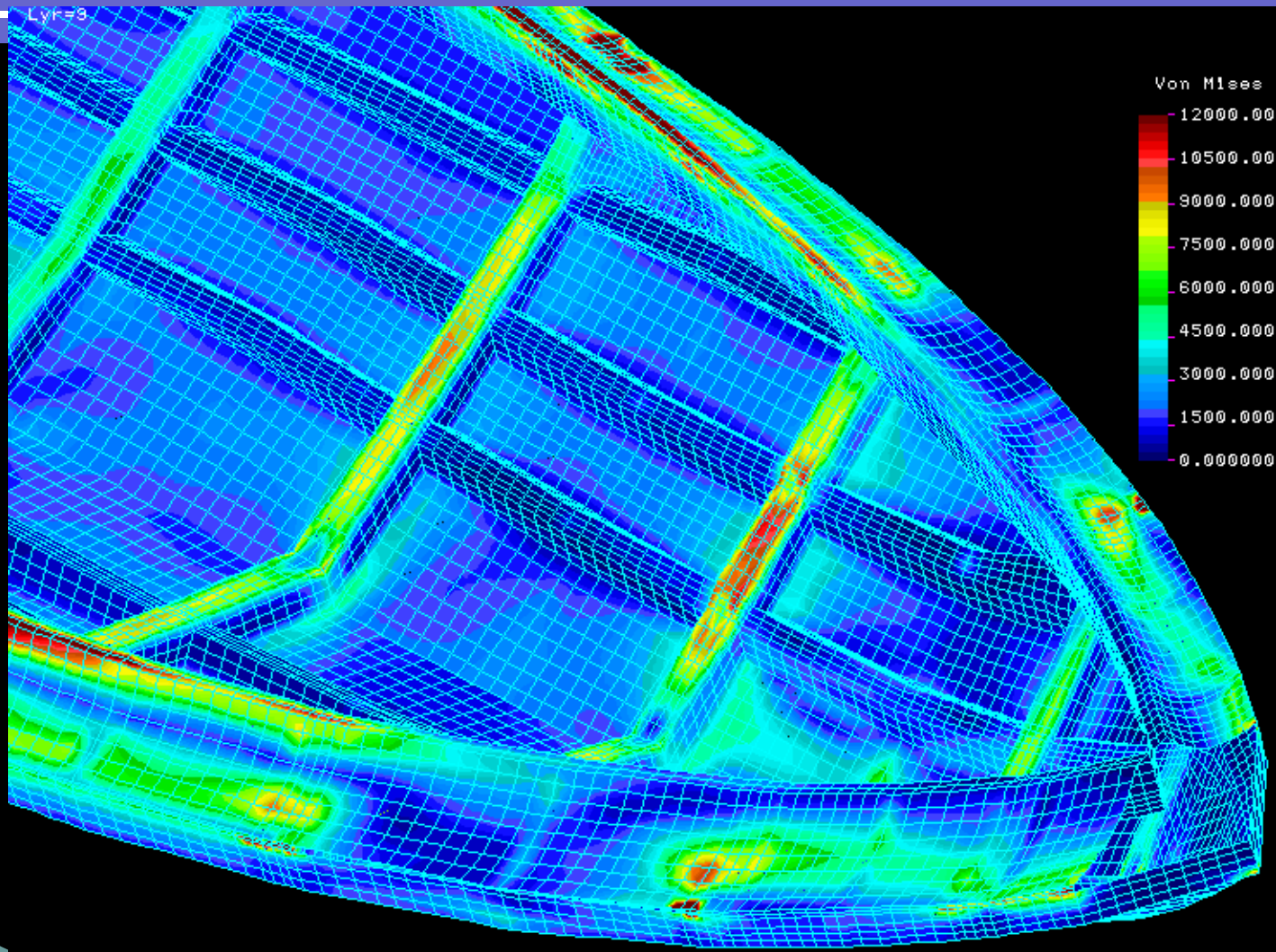


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LC7-FG- Longitudinal Stringer Cap Stress

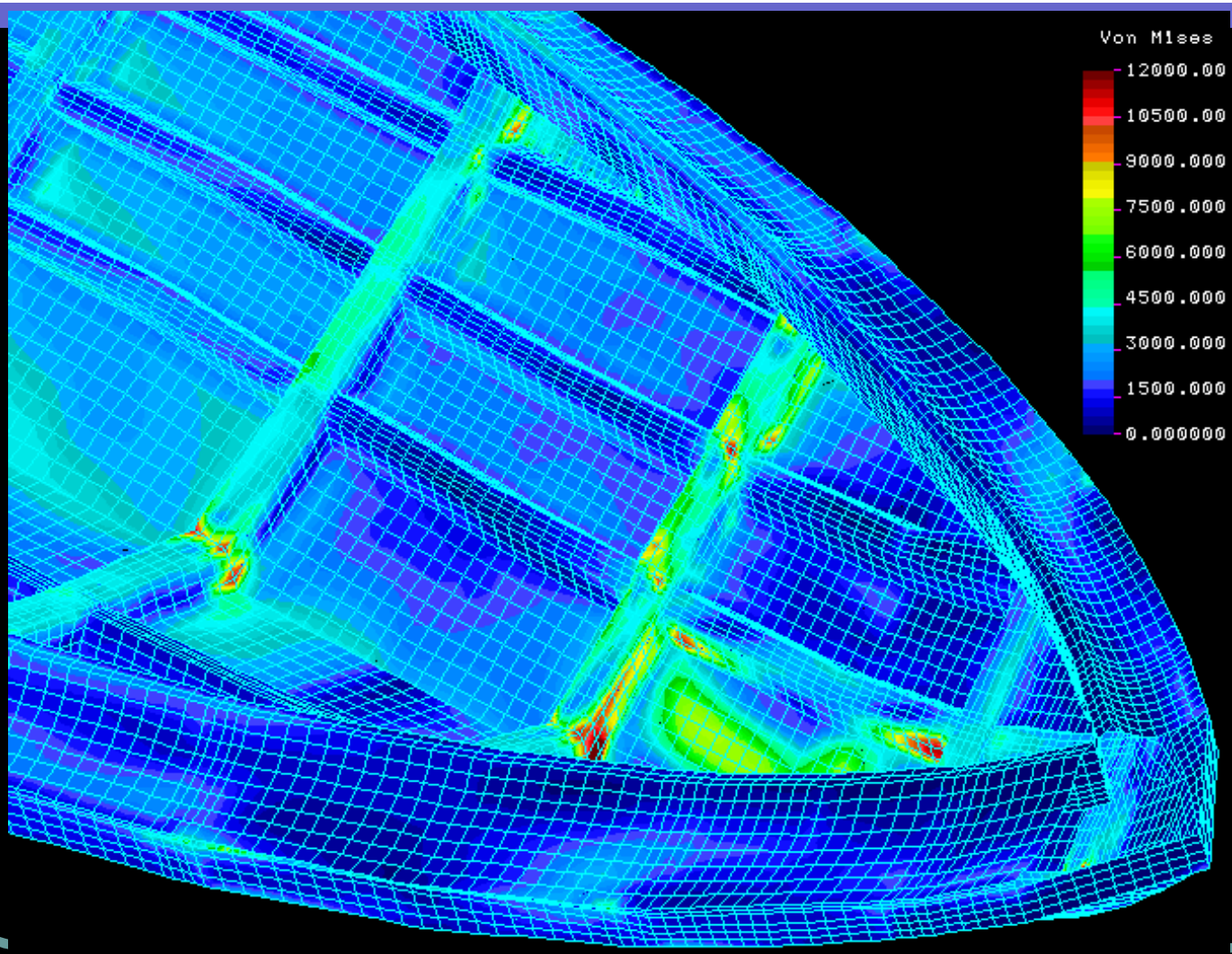


LC7-FG- Transverse Frame Cap Stress



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LC7-FG- 45 Ply Tab and Side Wall Stress



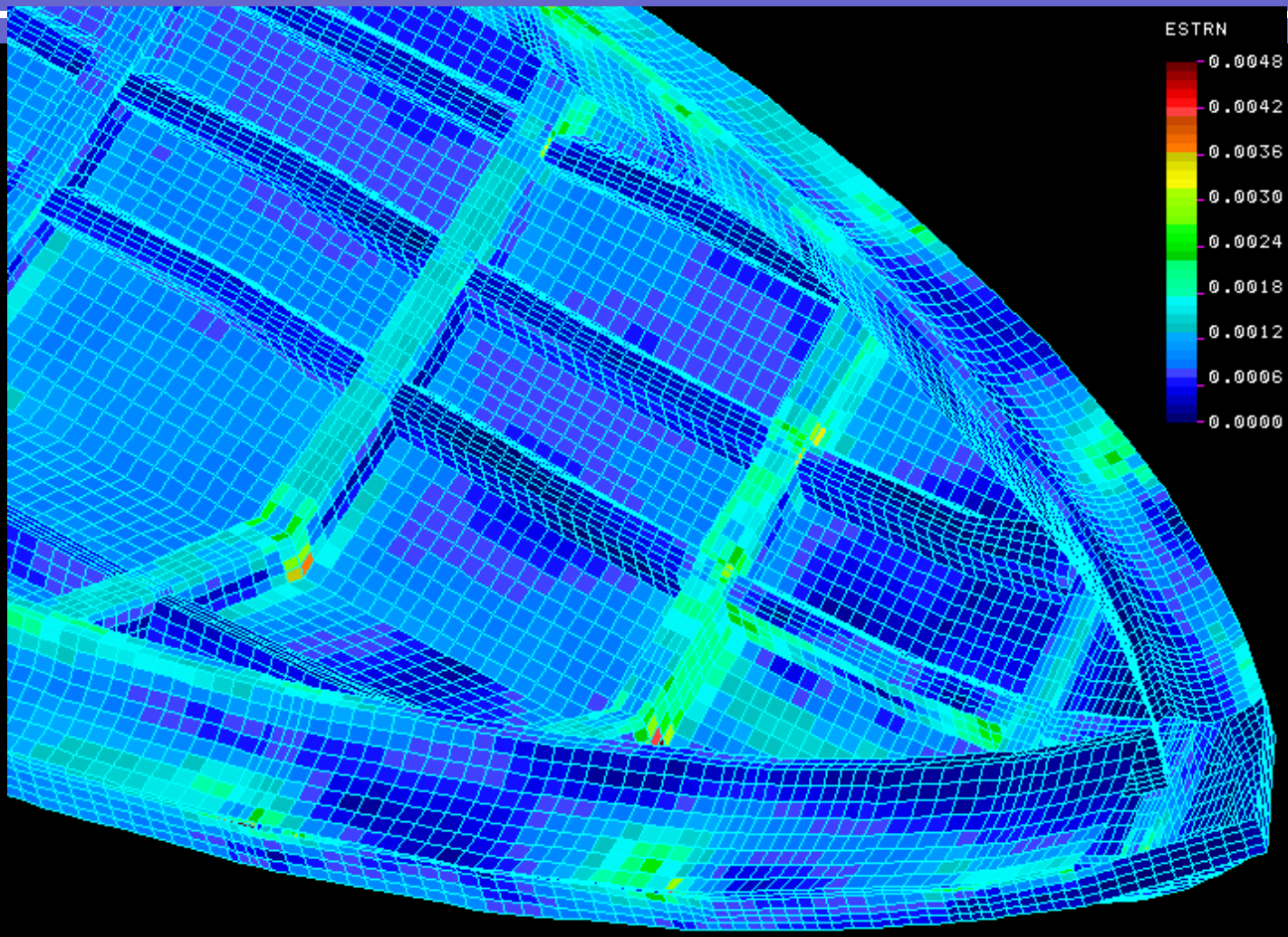
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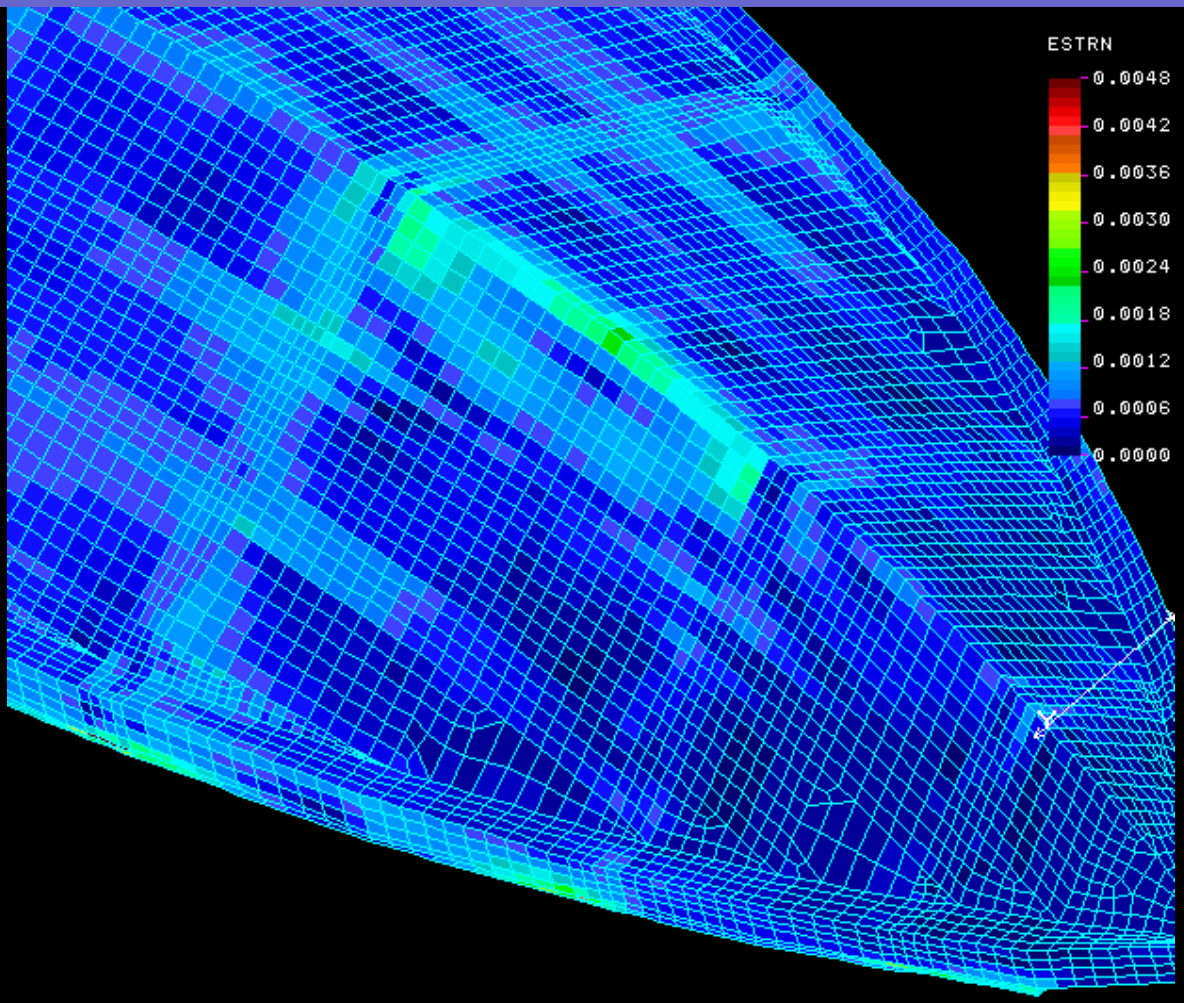
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LC7-FG- Inside Surface Strain



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LC7-FG- Outside Surface Strain



LC7-FG FI- Summary

- Hull range of deflection to 11.51 in.
- Maximum Hull strain 0.0024 in/in
- Maximum Hull stress 8,000
- Maximum framing strain 0.0033
- Maximum framing stress 12,000 psi

LC(1-7)- FG-SAS Summary

Range of maximum values in SAS cases

- Hull range of deflection -0.7 to 11.5 in.
- Maximum Hull strain 0.0033 in/in
- Maximum Hull stress 12,000 psi
- Maximum Frame strain 0.0036 in/in
- Max framing stress to 16,000 psi

136

11M- FEA Analysis: Boat Lifting Points (B.L.P.)



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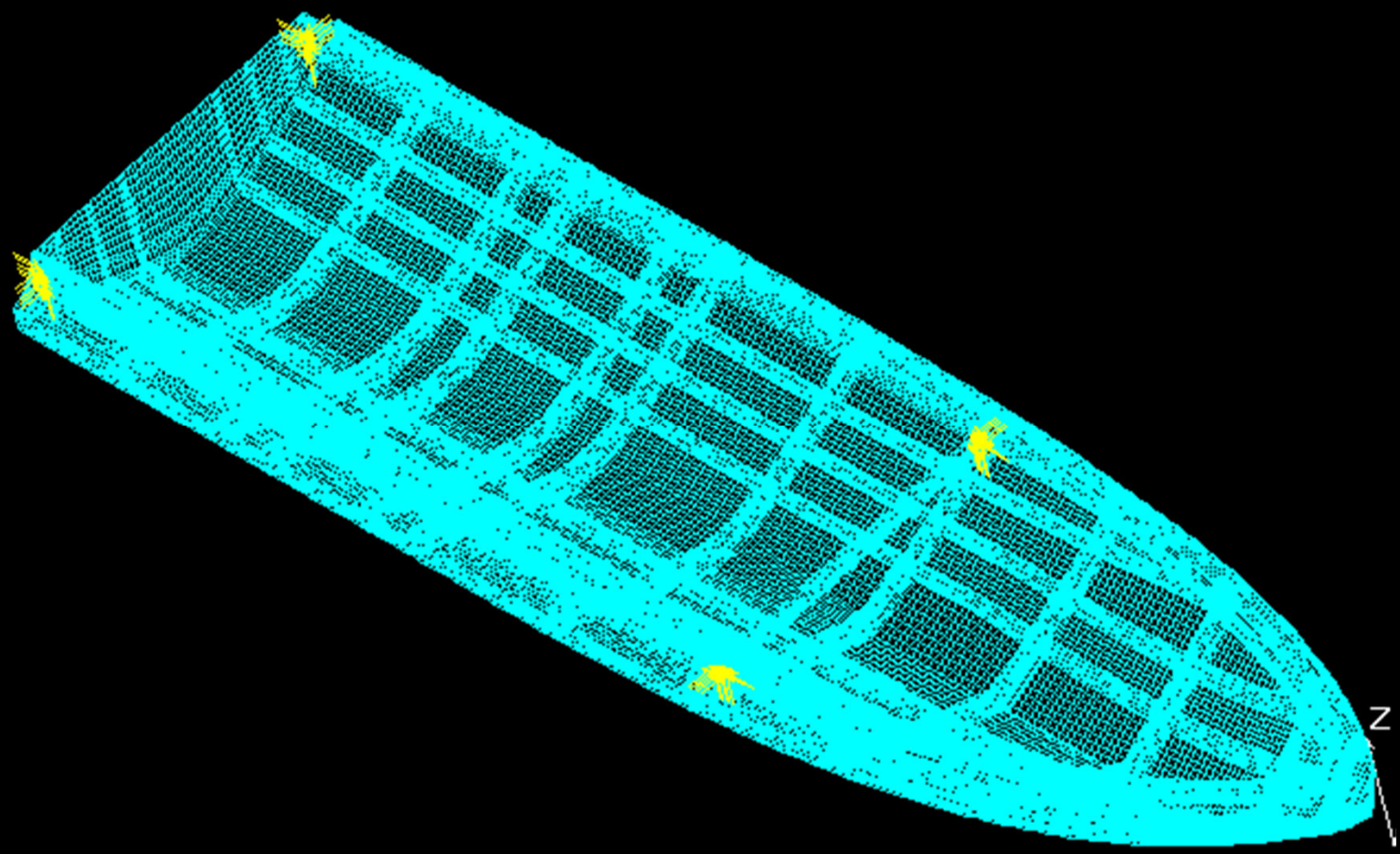
LC8 - BLP- Lift Load

- 4 Point Lift
- Transom is Aft Lift Point
- Intersection of Side wall and floor of Cockpit is Fwd Lift Point
- 55,490 lbs at engine mounts (from constraints)
- -50,110 lbs distributed load (-1 lb at each of 50,110 nodes)
- Total weight 105,600 lbs (6 x 17,600 lbs

LC8 - BLP- Load Data

- Vertical loads
  - 26,400 lbs at each point
  - 105,600 lbs total (6 x 17,600 lbs)
- Transverse loads
  - -1056 lbs stbd side lift points
  - 1056 lbs port side lift points
- Longitudinal loads
  - 13,200 lbs at aft points
  - -13,200 lbs at fwd points

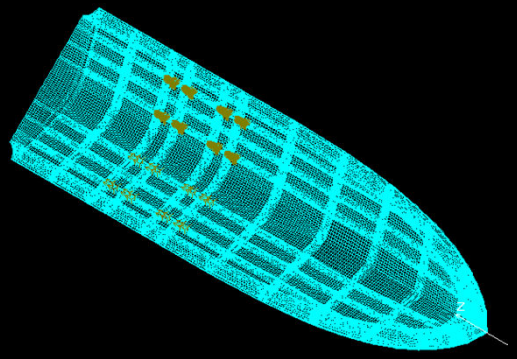
LC8 - BLP- Force Vector at Lift Points



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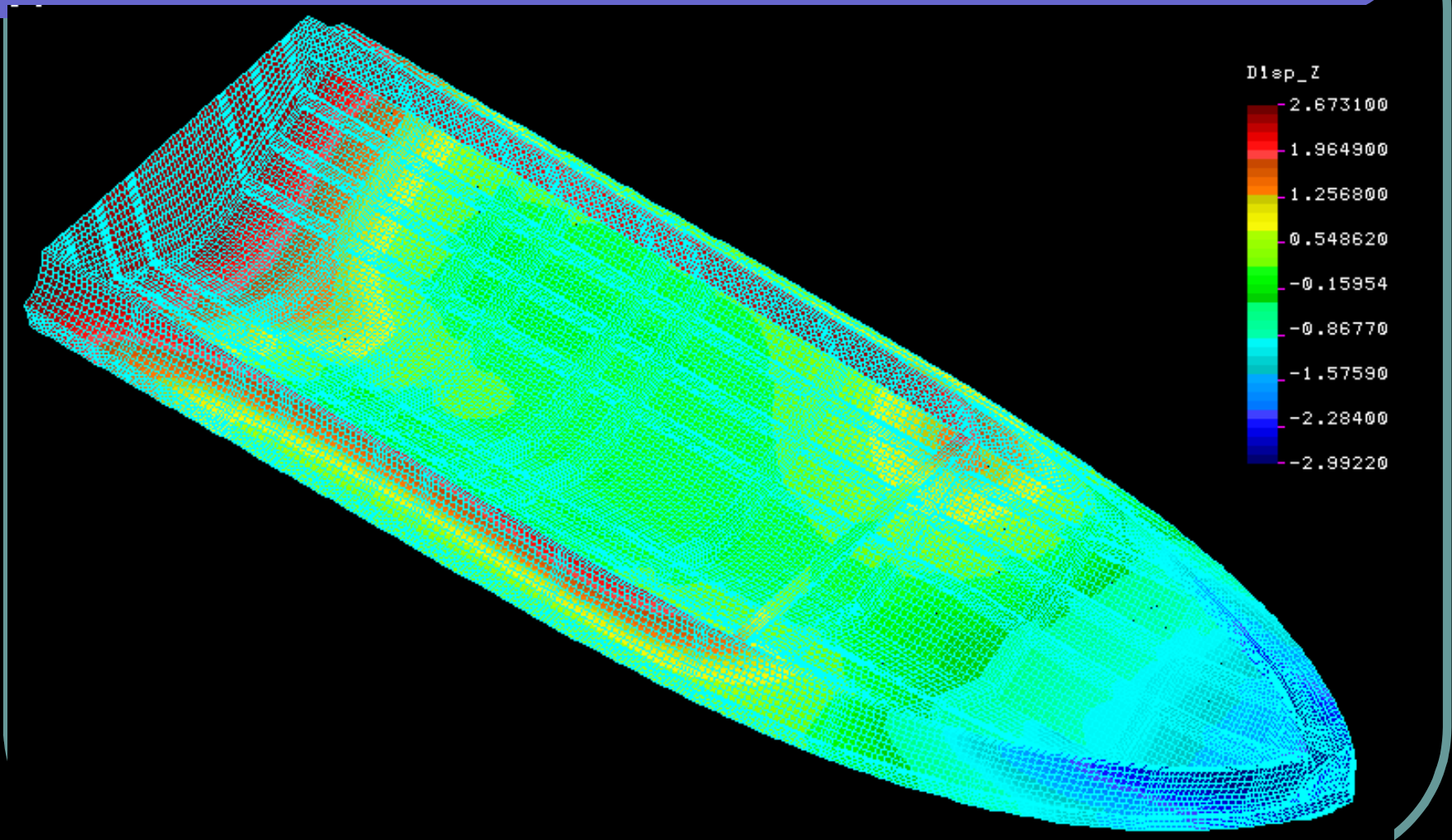
LC8 - BLP- Constraints

- Displacements set to zero at selected frame intersections
- Constraints necessary to obtain solution
- Reaction forces at constraints $F_r < 1$ lb
- Thus constraints do not affect results

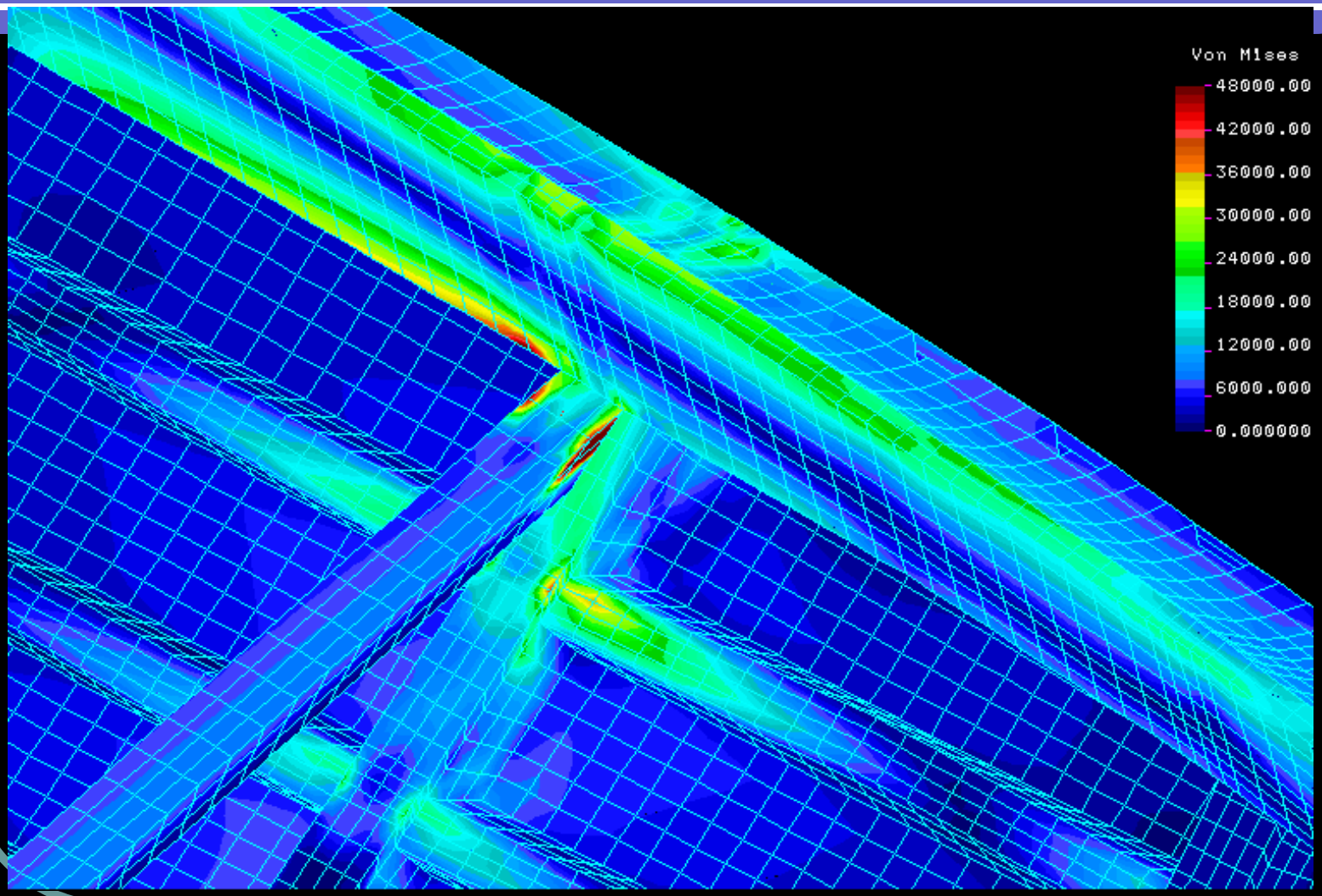


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LC8 - BLP- Vertical Displacement

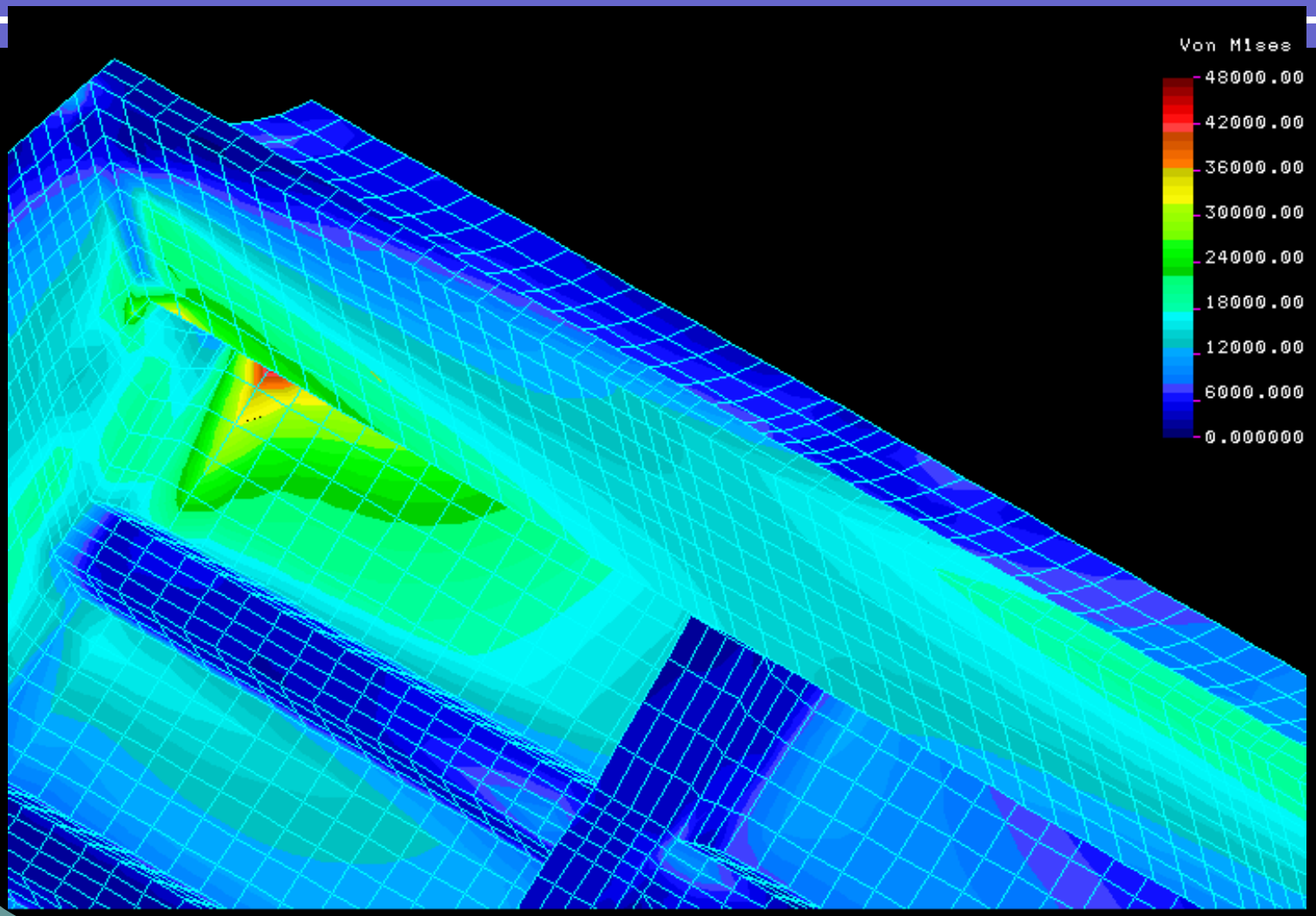


BLP- Longitudinal Ply- Fwd Lift Point

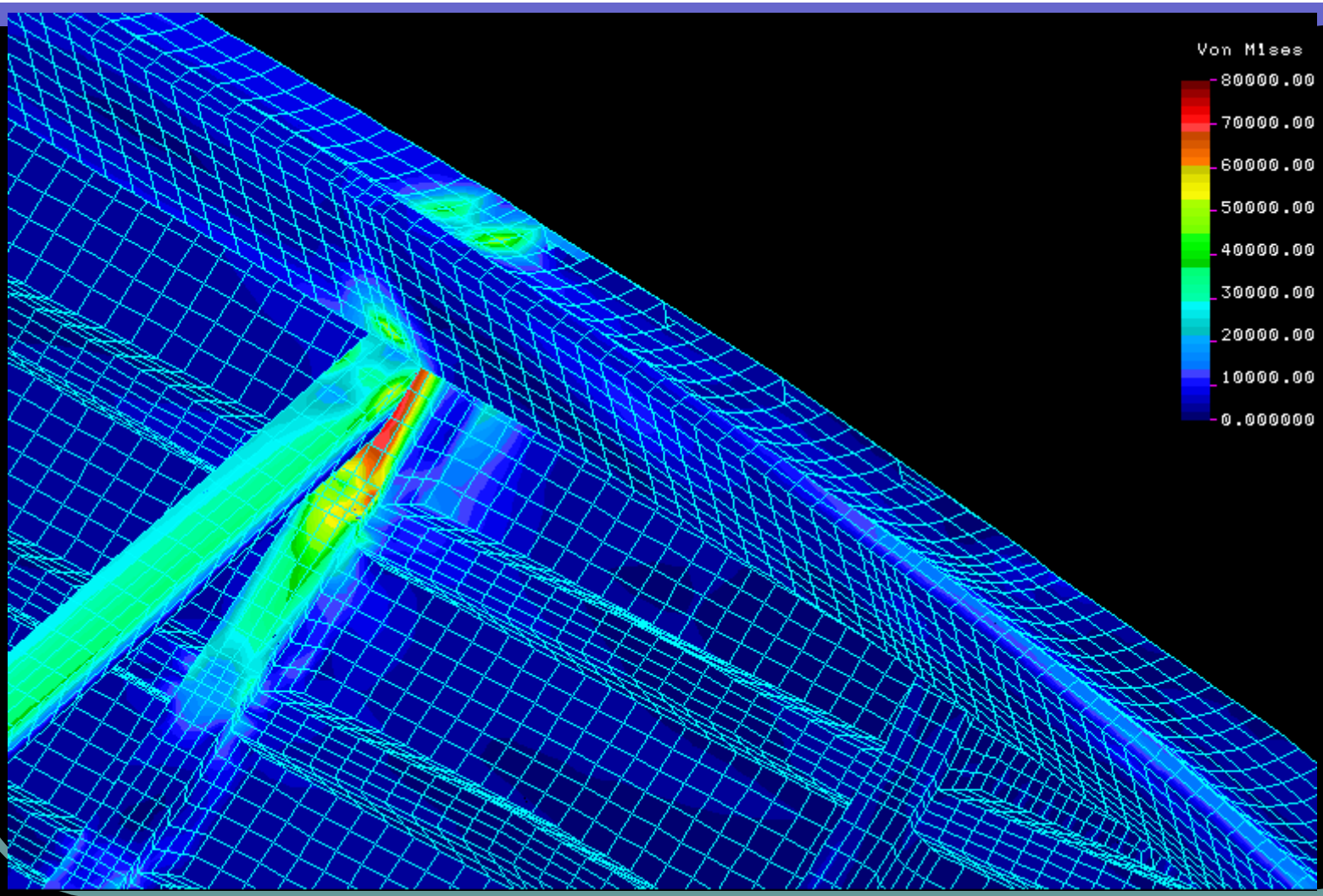


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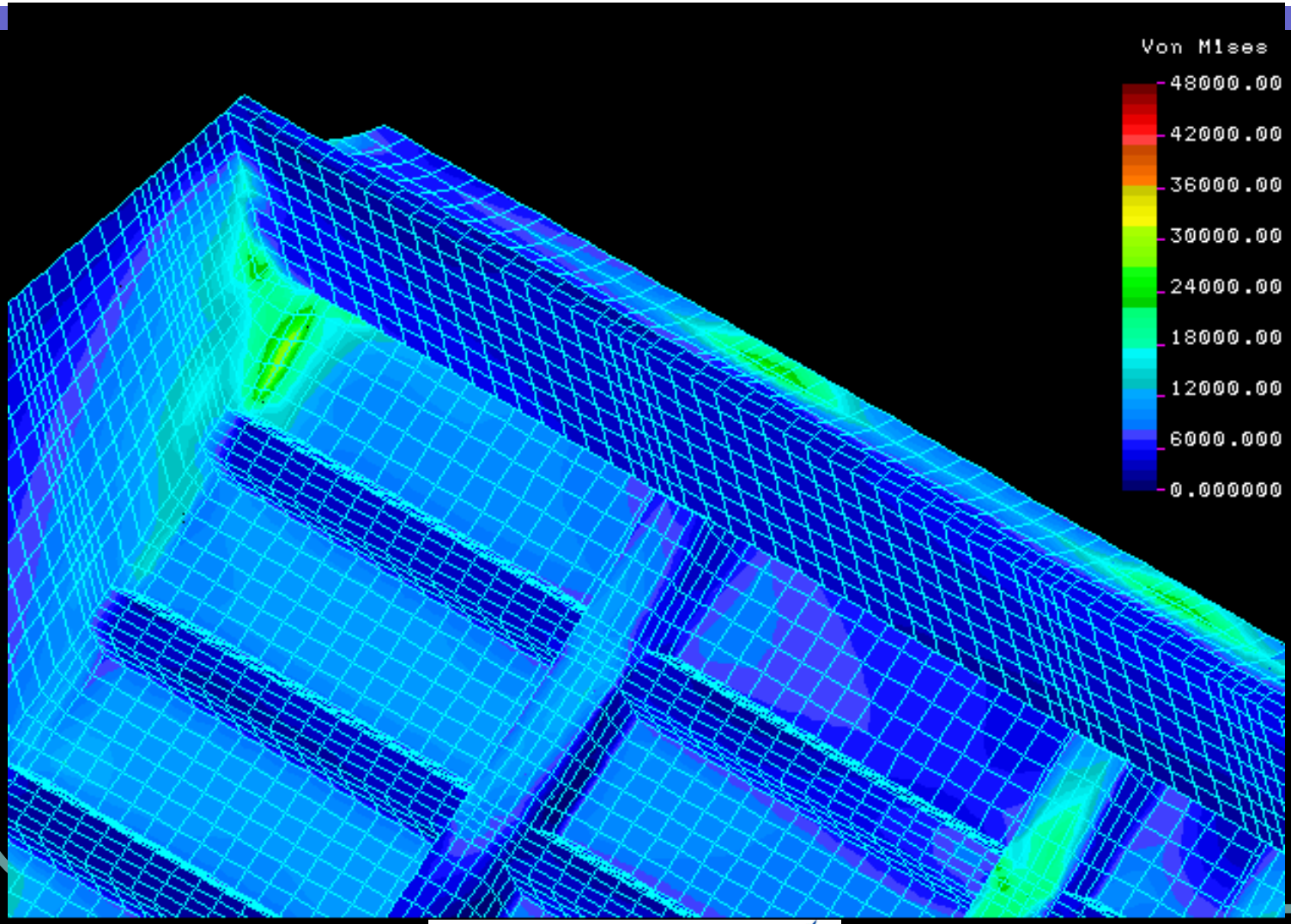
LC8 - BLP- Longitudinal Ply- Aft Lift Point



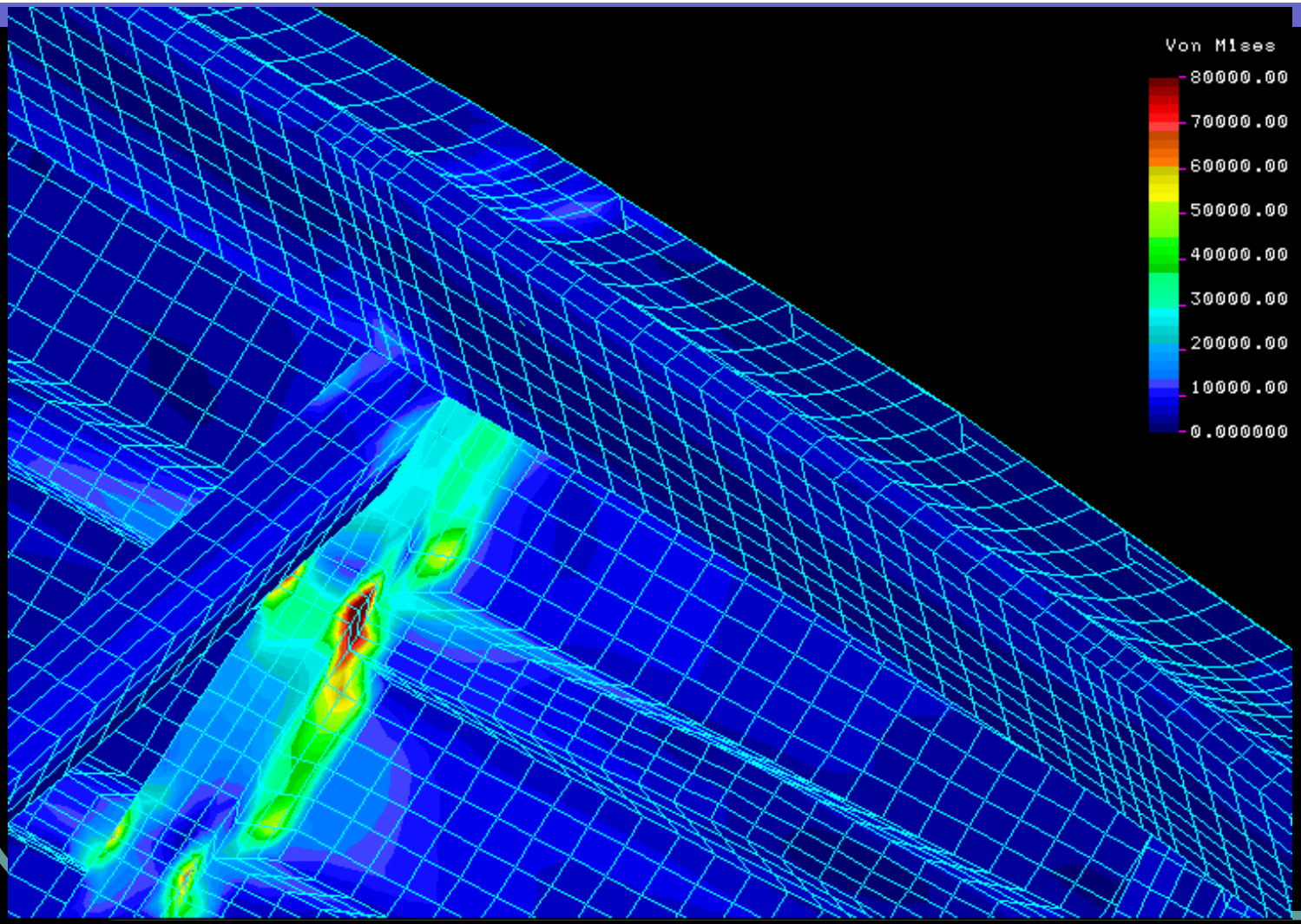
LC8 - BLP-Transverse Ply- Fwd Lift Point



LC8 - BLP- Transverse Ply- Aft Lift Point



LC8 - BLP- 45Ply- Fwd Lift Point



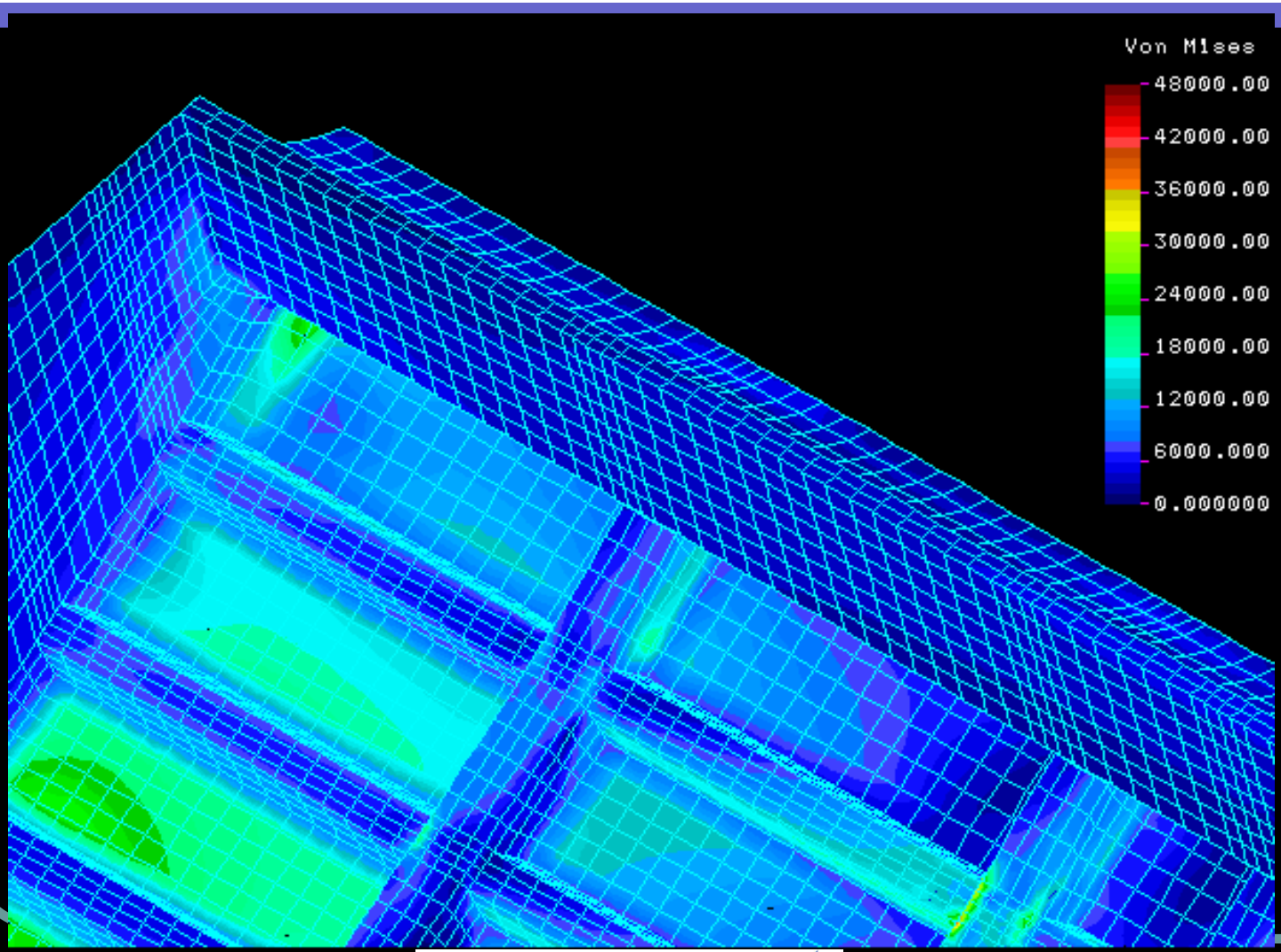
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LC8 - BLP- 45 Ply- Aft Lift Point



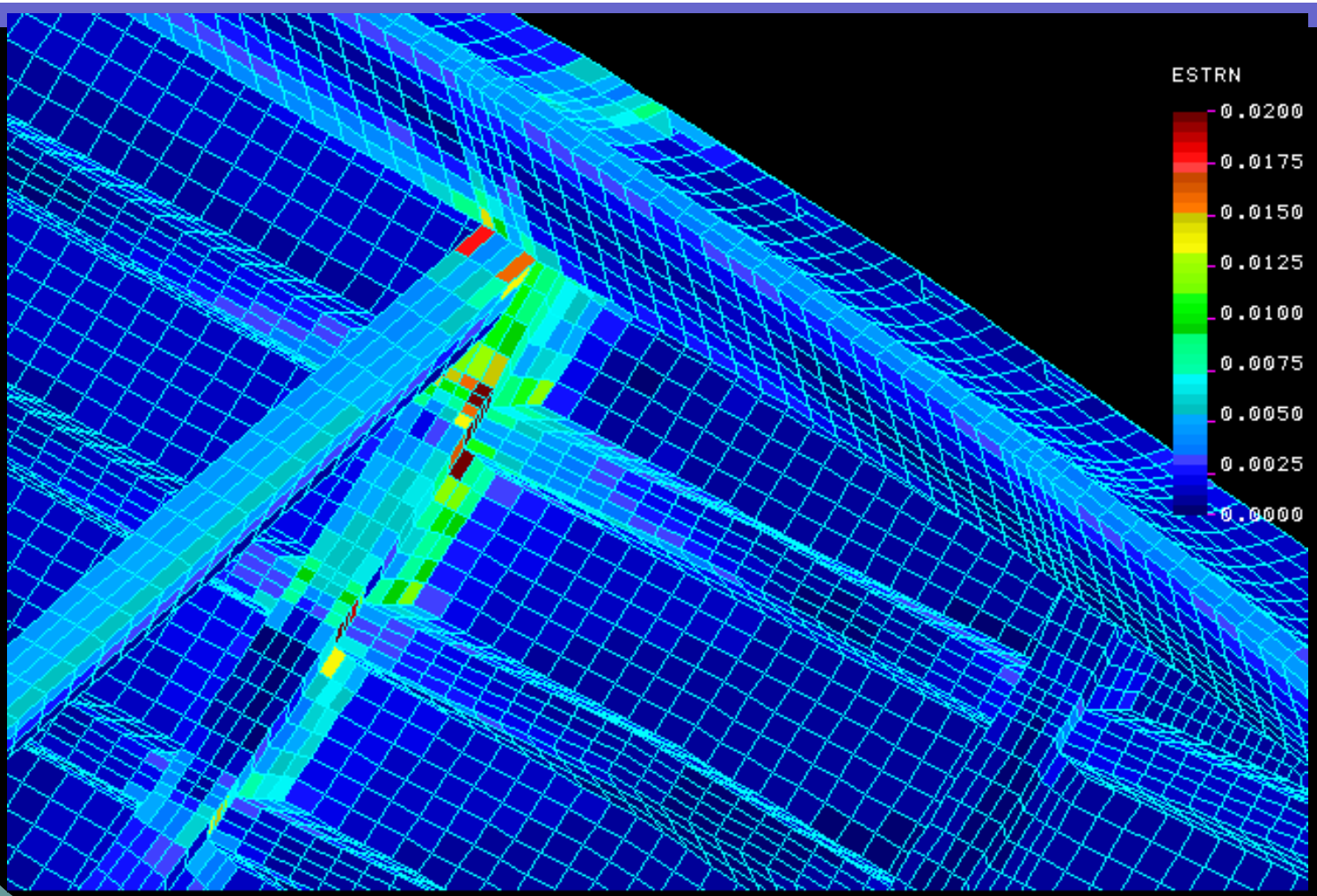
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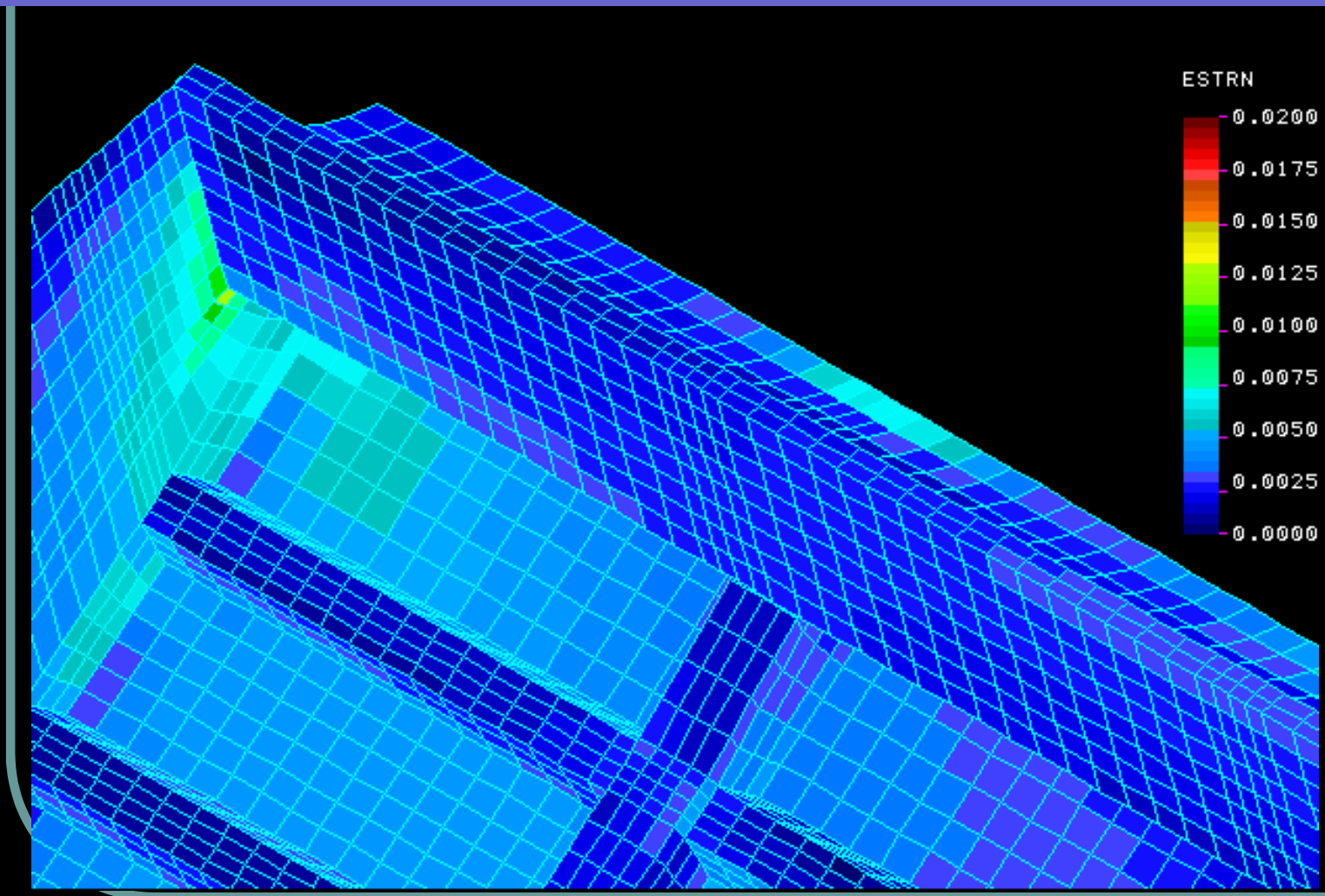
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LC8 - BLP- Strain- Fwd Lift Point



LC8 - BLP- Strain- Aft Lift Point



LC8 - BLP- Lift Analysis Summary

- Hull range of deflection -3.0 to 2.7 in.
- Maximum strain 0.02 in/in
- Maximum long stress 48,000 psi
- Maximum Transverse stress 70,000 psi
- Maximum 45 axis stress 80,000

151

11M- FEA Analysis: Gun Mount (G.M.L.) (G.M.T.)



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Gun Mount Framing Notes

- This is a stiffness design, thus stresses are low
- Four transverse frames, TR2030X, are placed on 3.5 in centers
- Skin laminate is 4 layers of E LTM 3610 (entire foredeck, including tube support areas)
- Frame laminate
  - 24 oz (+/-45) on PRISMA beam
  - 4 layers 4” wide E LM 1810 warp uni on frame caps
  - E BXM 2408 (+/-45) cover fabric (overlapping adjacent tabs)

LC9- GML- Long. Loading

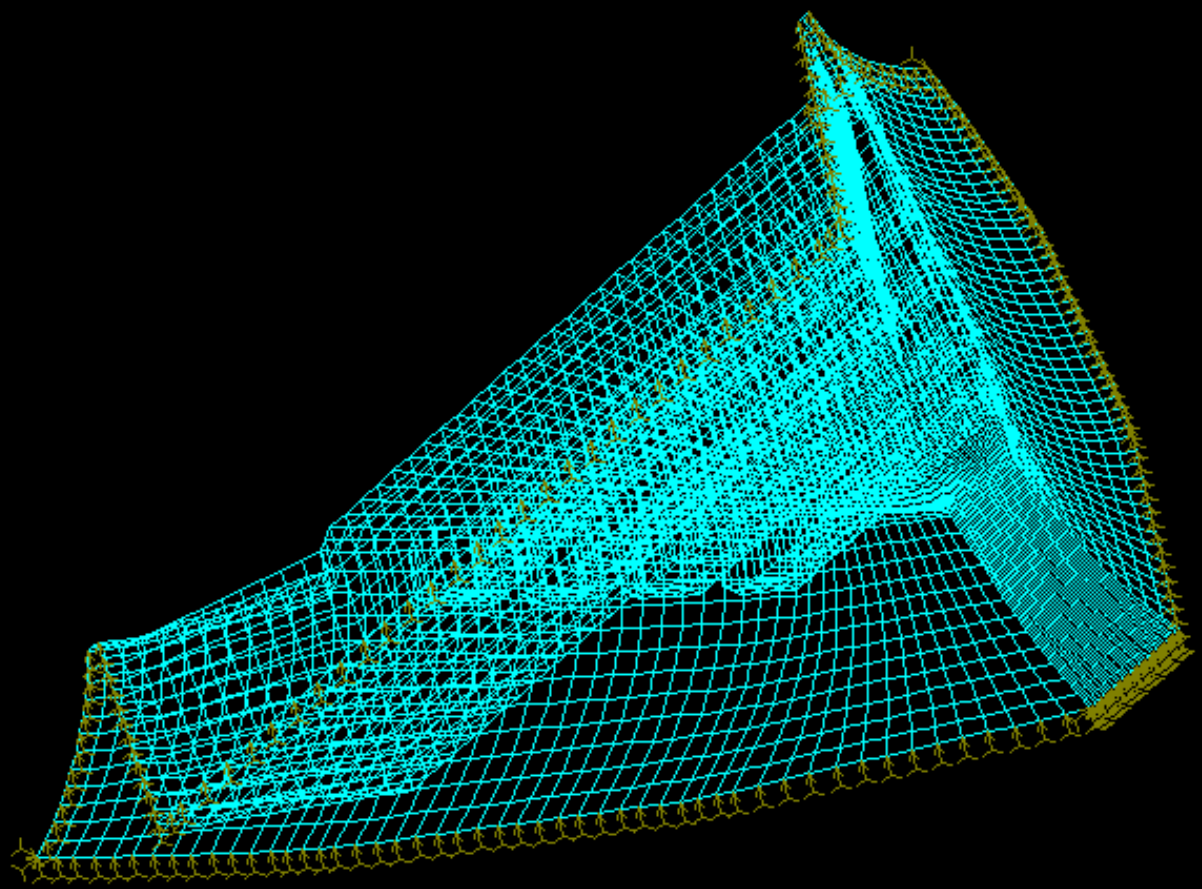
Forward

- Two bolts
- Tensile loading 2250 lbs each bolt

Aft

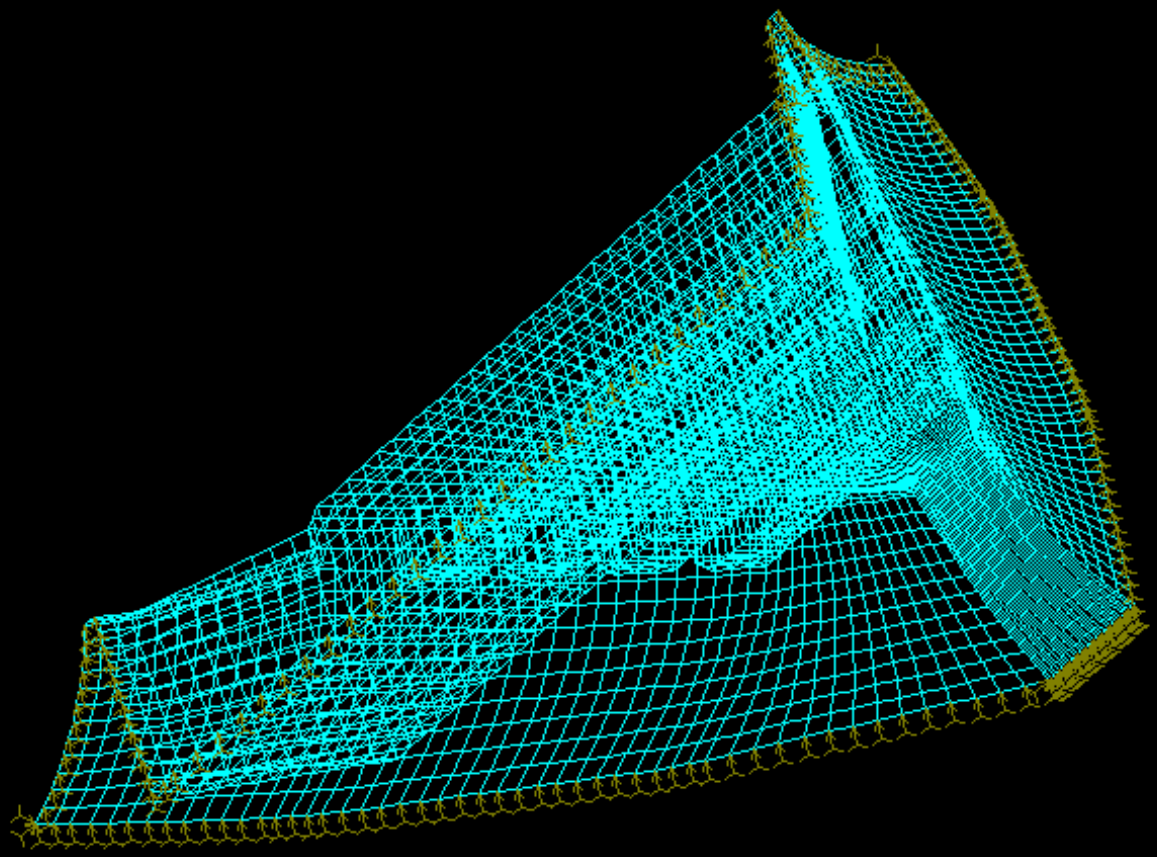
- Loading at 13 nodes along aft edge of mounting plate
- Compressive loading 347 lbs each point

LC9- GML- Long. Elements



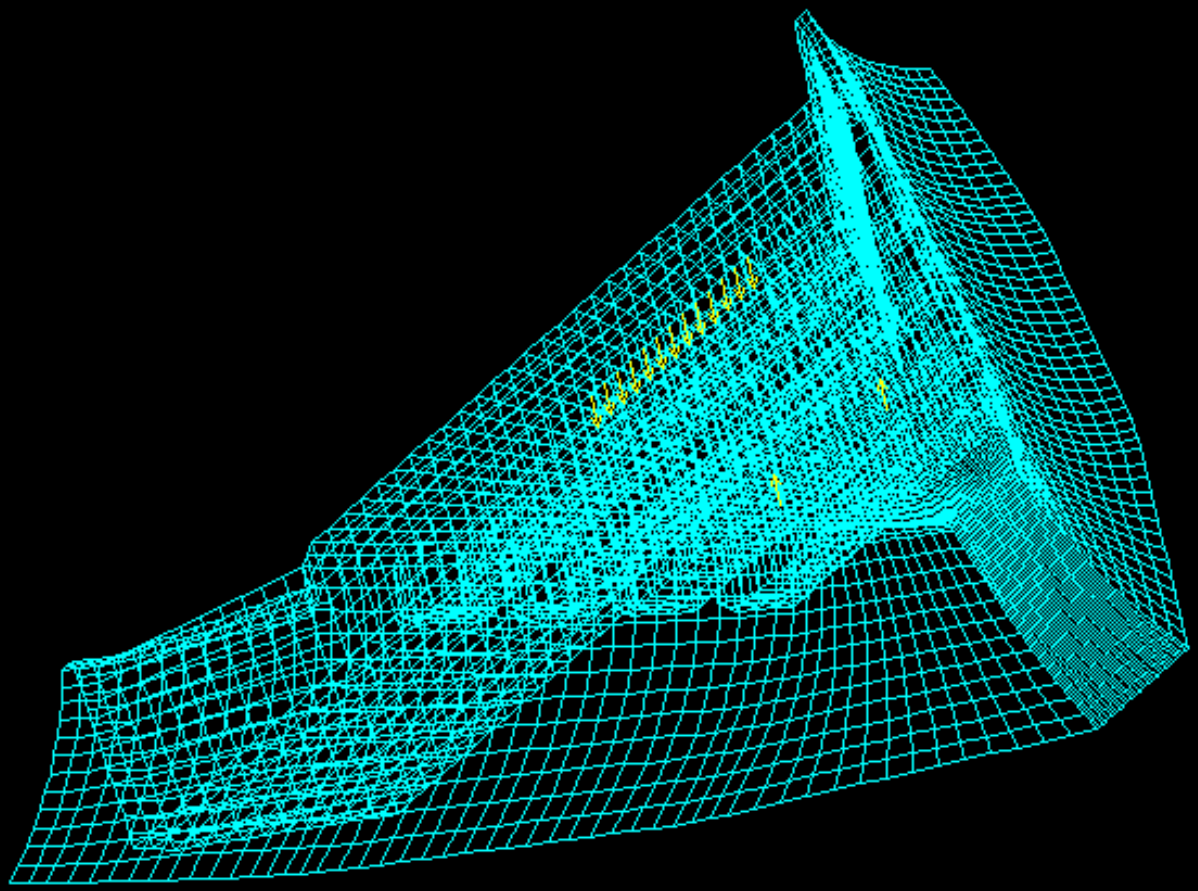
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LC9- GML- Long. Constraints



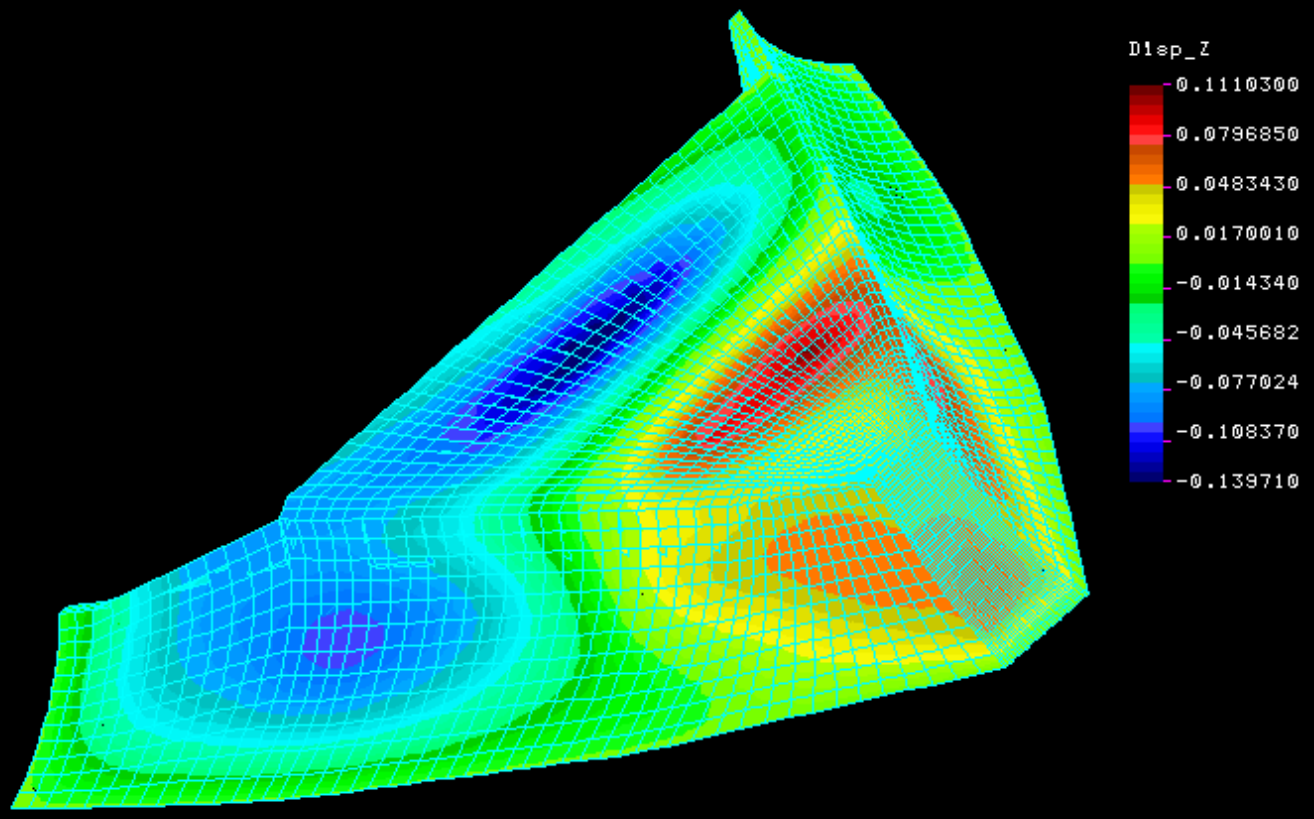
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LC9- GML- Long. Loading

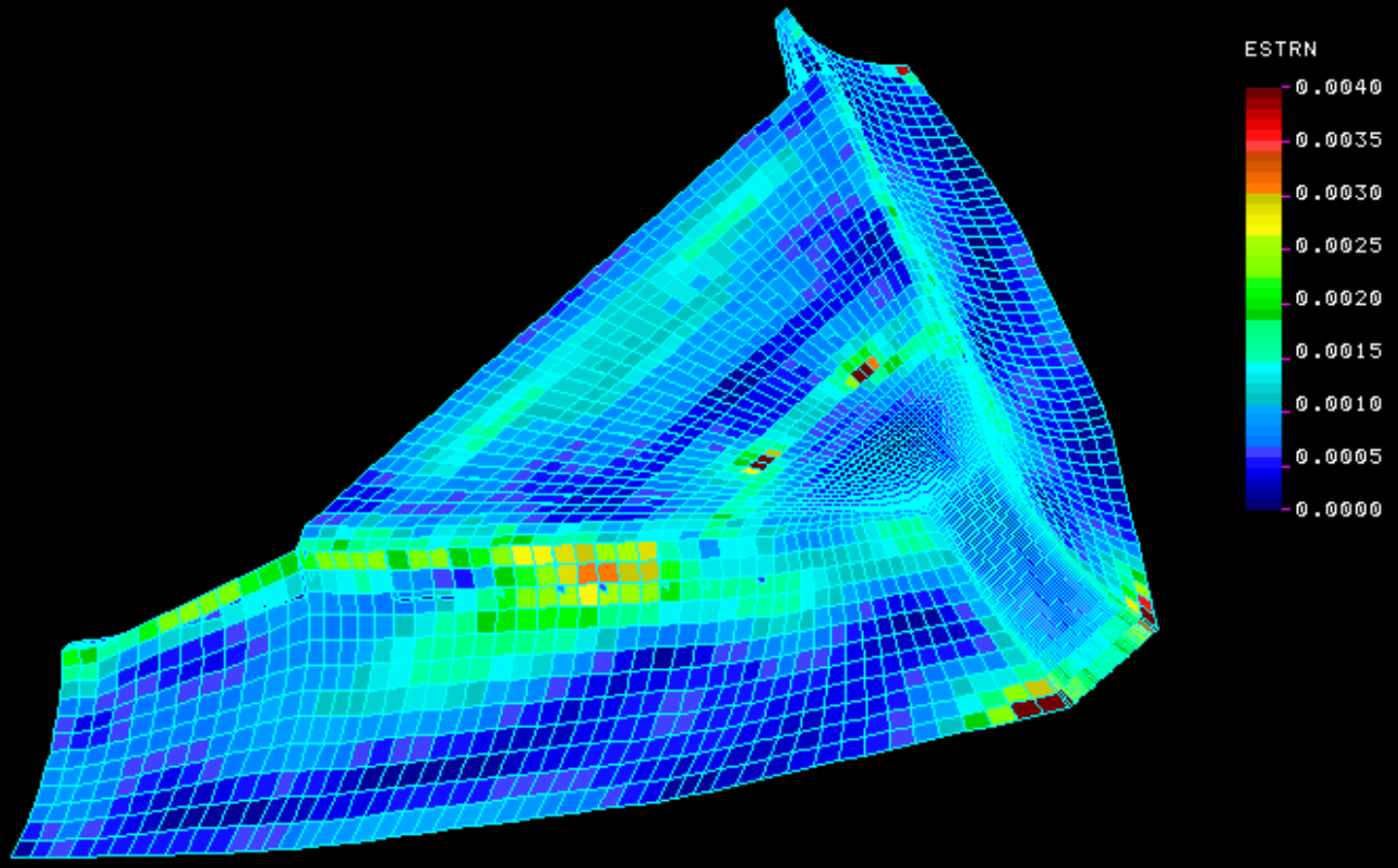


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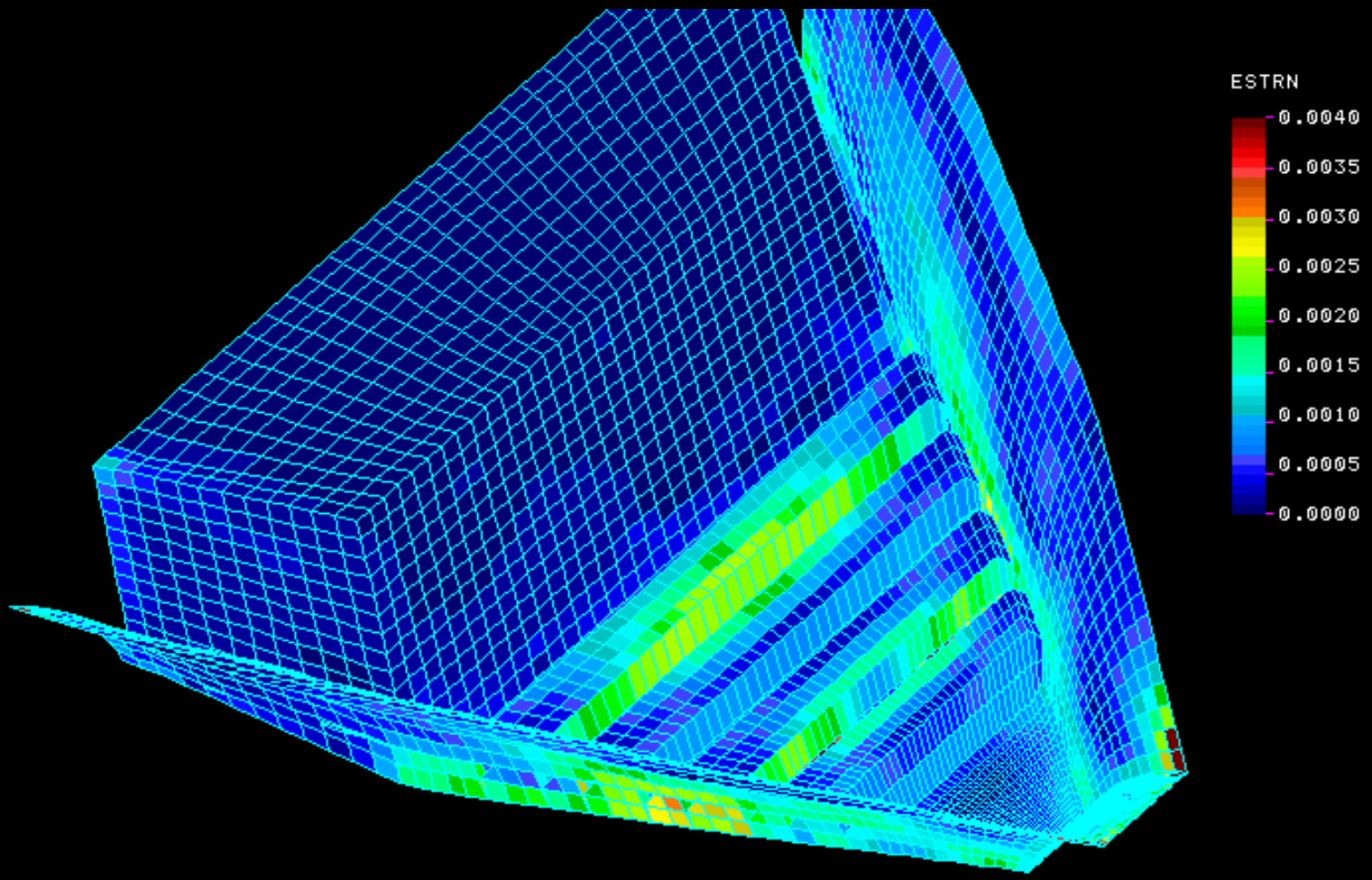
LC9- GML- Long. Loading Vertical Displacement



LC9- GML- Long. Loading 1st Layer Strain (Outside View)

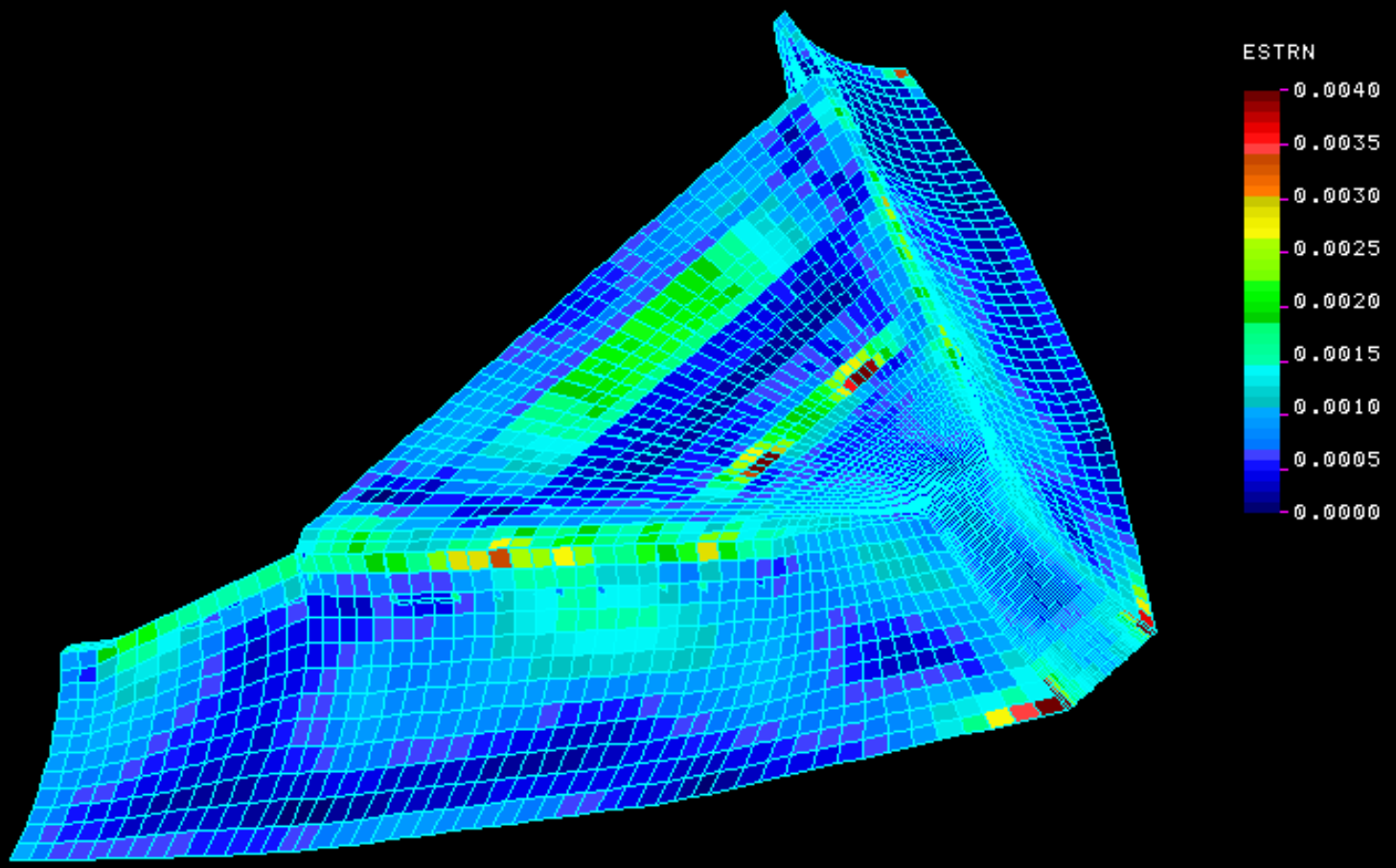


LC9- GML- Long. Loading 1st Layer Strain (Inside View)



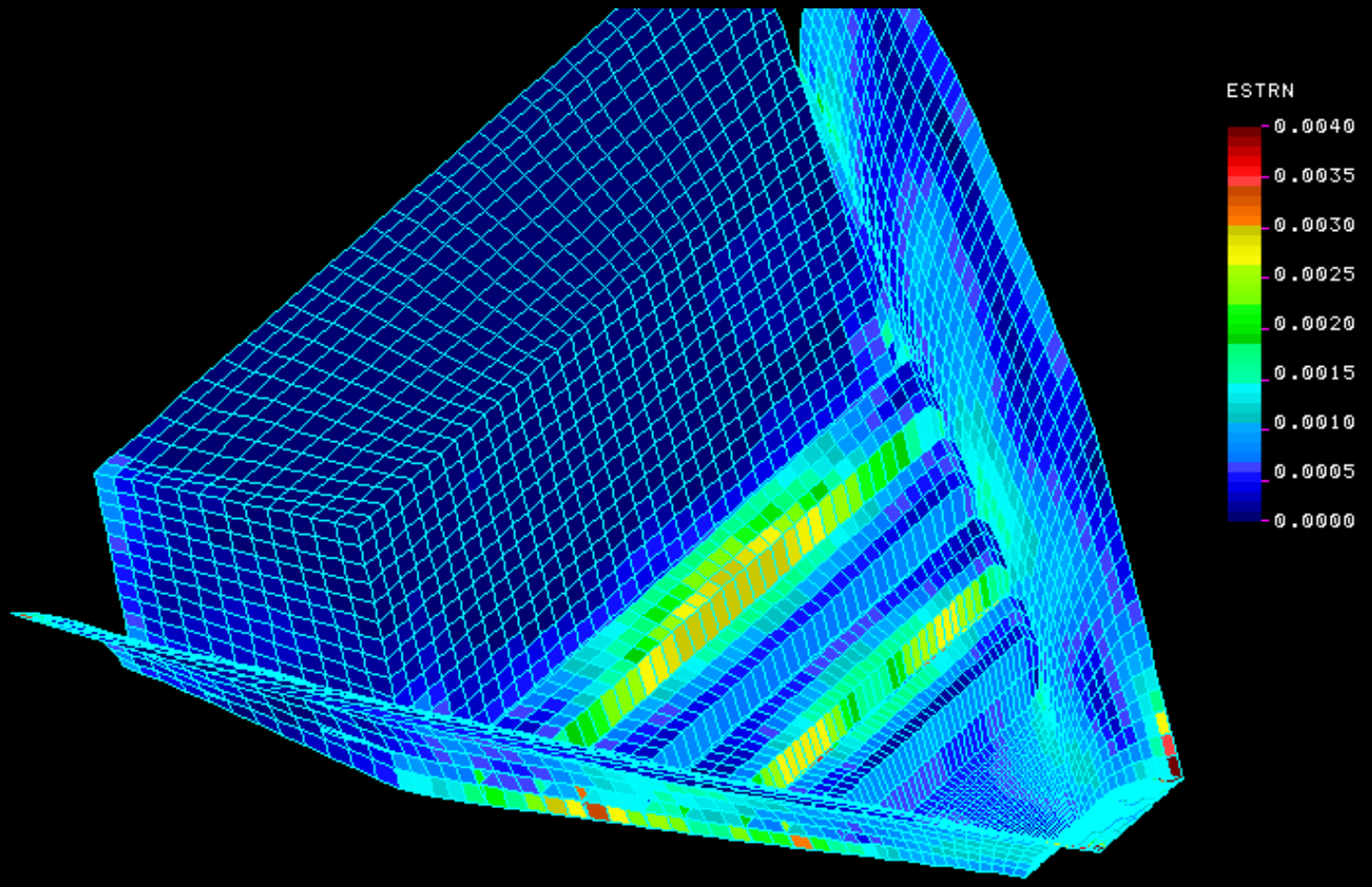
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LC9- GML- Long. Loading Last Layer Strain (Outside View)



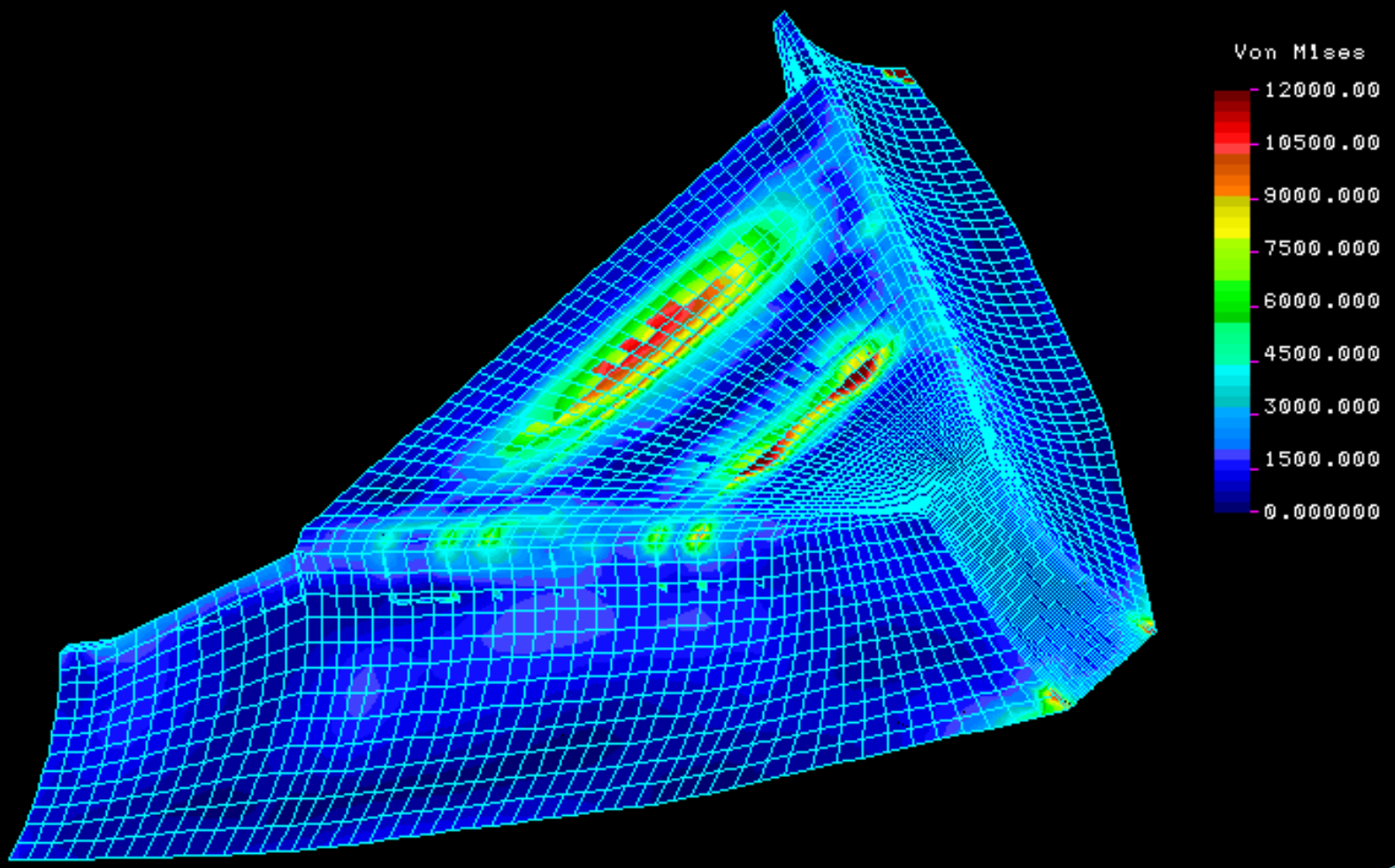
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LC9- GML- Long. Loading Last Layer Strain (Inside View)



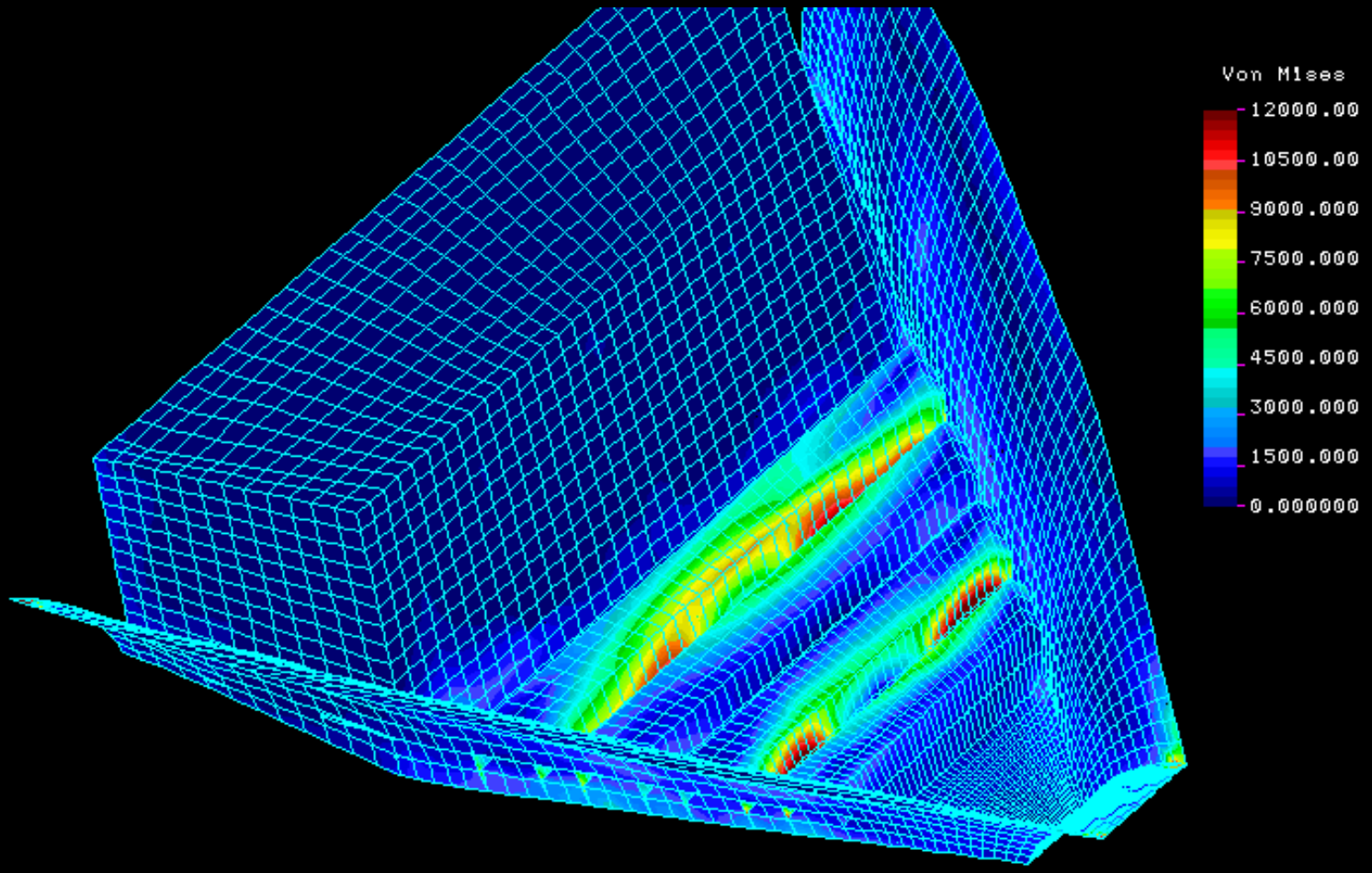
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LC9- GML- Long. Loading Longitudinal Ply Stress (Outside View)



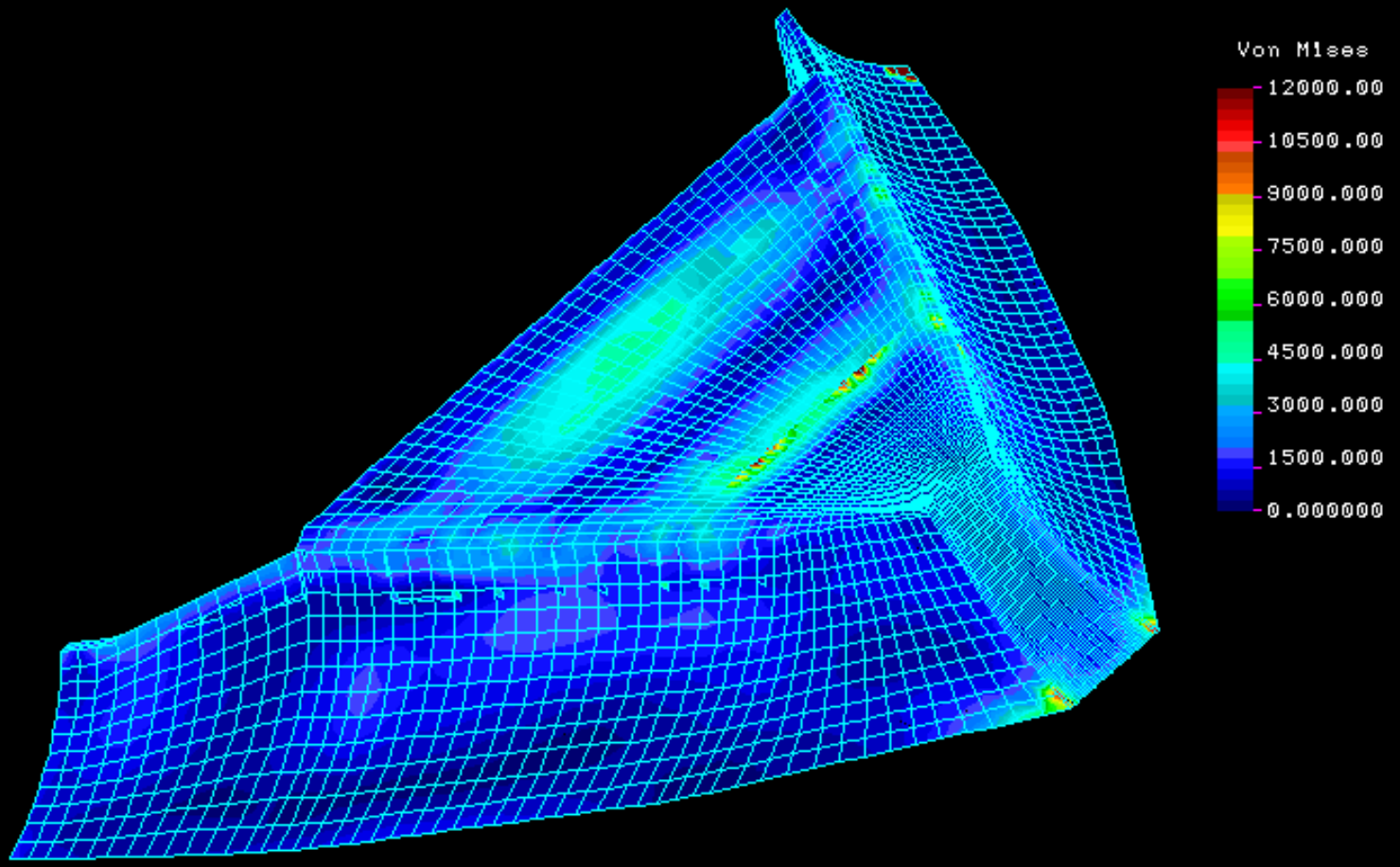
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LC9- GML- Long. Loading Longitudinal Ply Stress (Inside View)



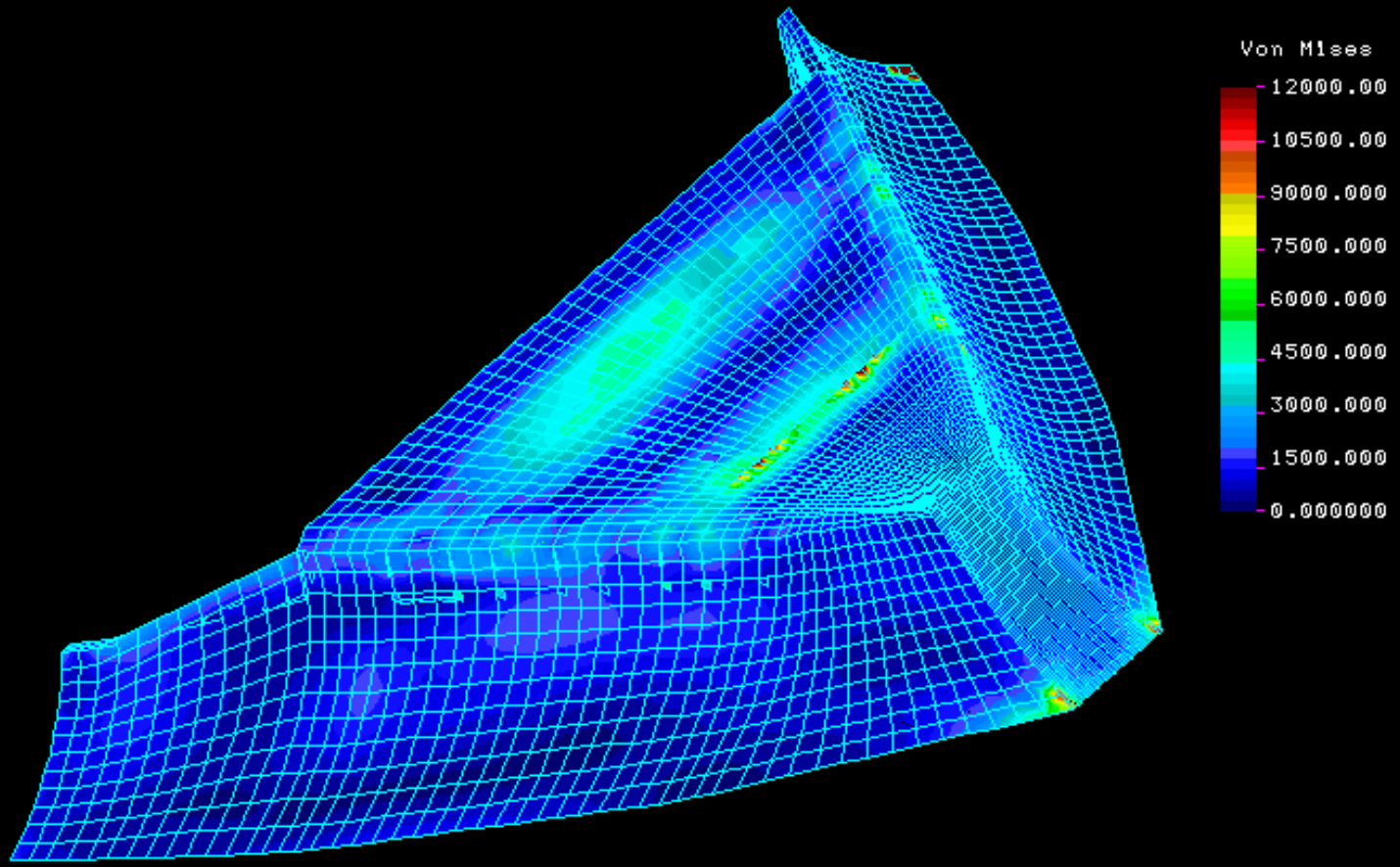
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LC9- GML- Long. Loading Transverse Ply Stresses (Outside View)



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LC9- GML- Long. Loading Transverse Ply Stress (Inside View)



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LC9-11M- G.M.L- Summary

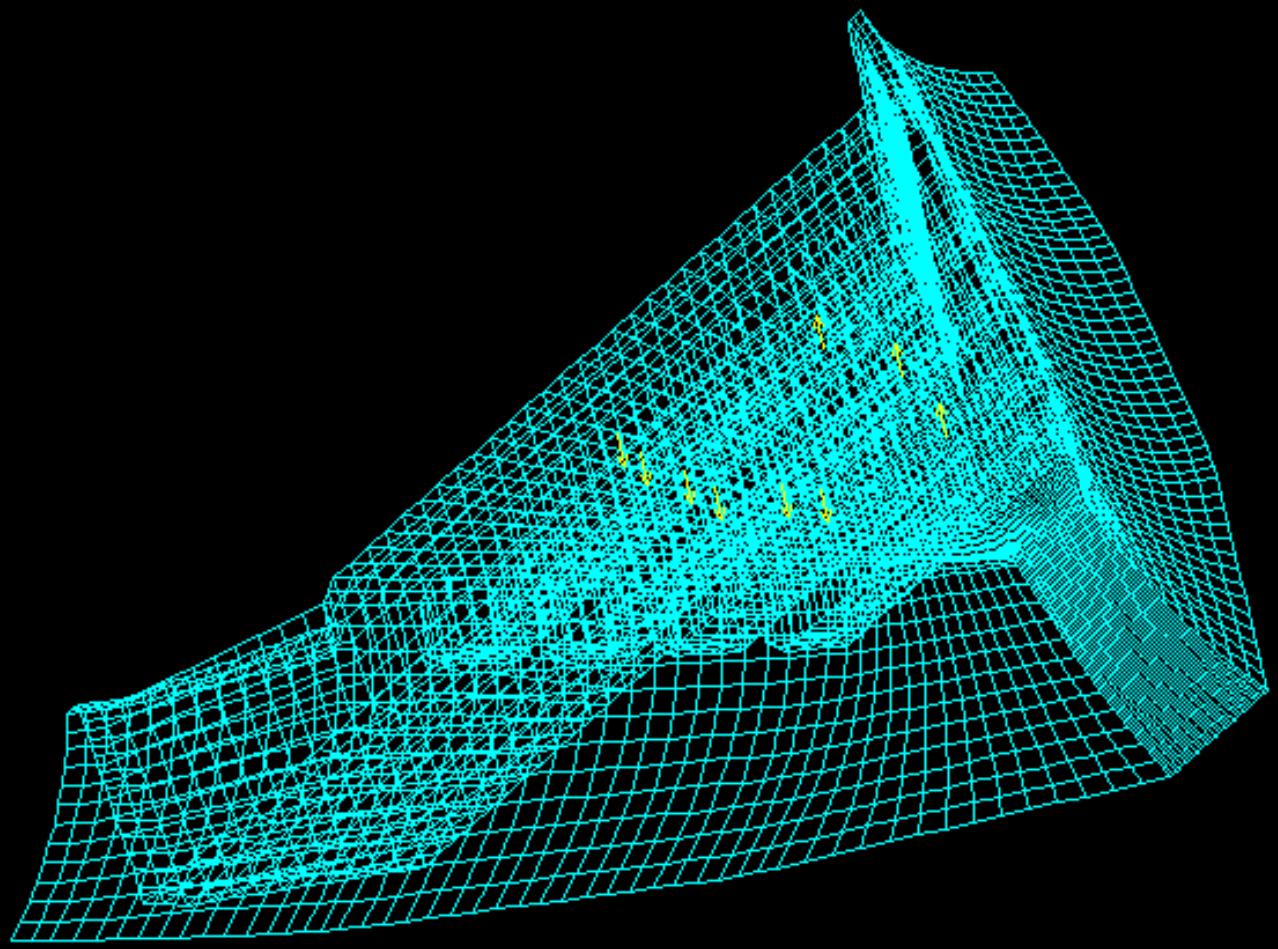
- Range of deflection -.14-.11 in.
- Maximum strain .004 in./in.
- Maximum longitudinal stress 12,000 psi
- Maximum transverse stress 12,000 psi

LC10- GMT- Transverse Loading

Port side
- Three bolts
- Tensile load of 1500 lbs each bolt

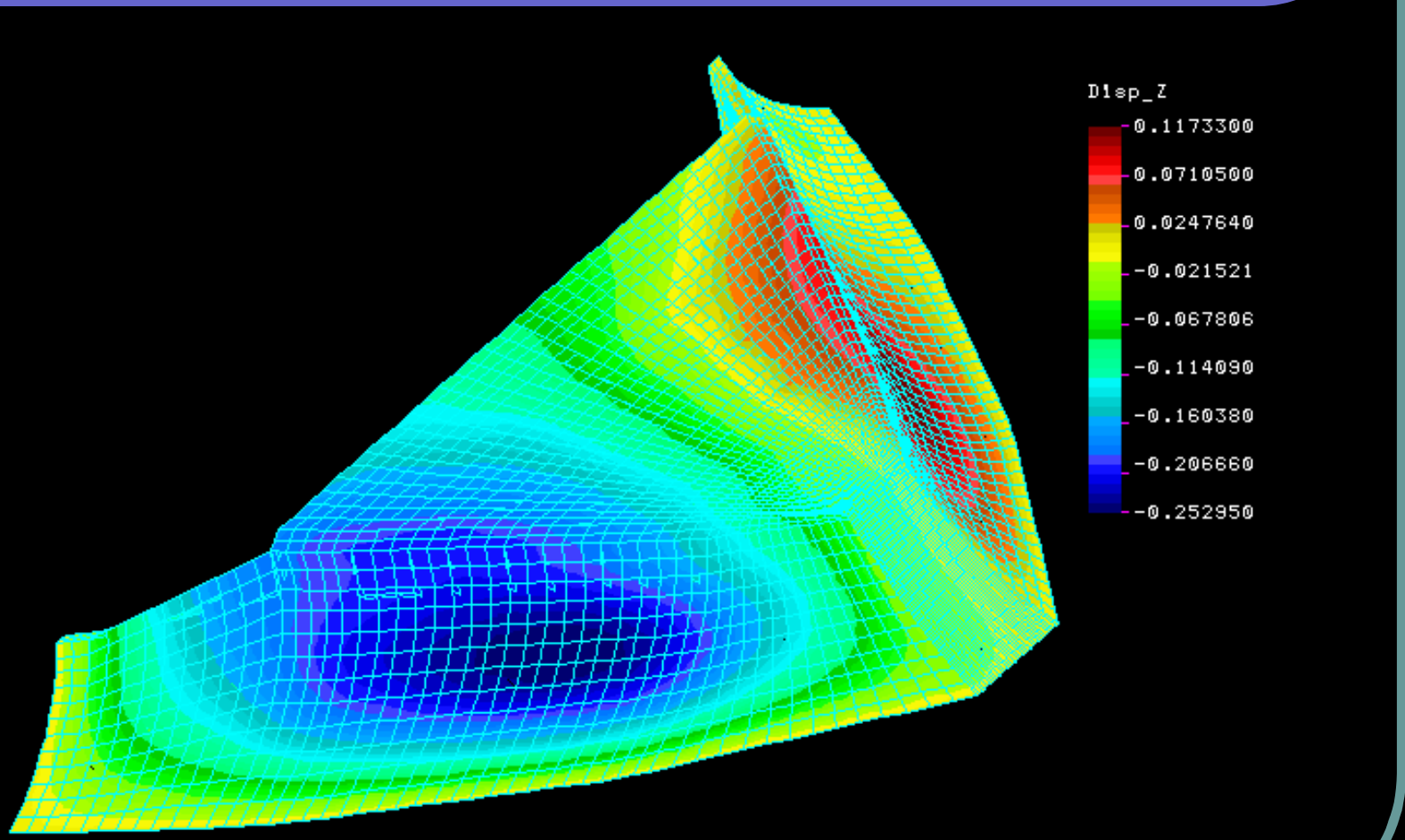
Starboard Side
- Six point loads (where mounting plate edge crosses frame sides)
- Compressive load of 750 lbs each point

LC10- GMT- Trans. Loading



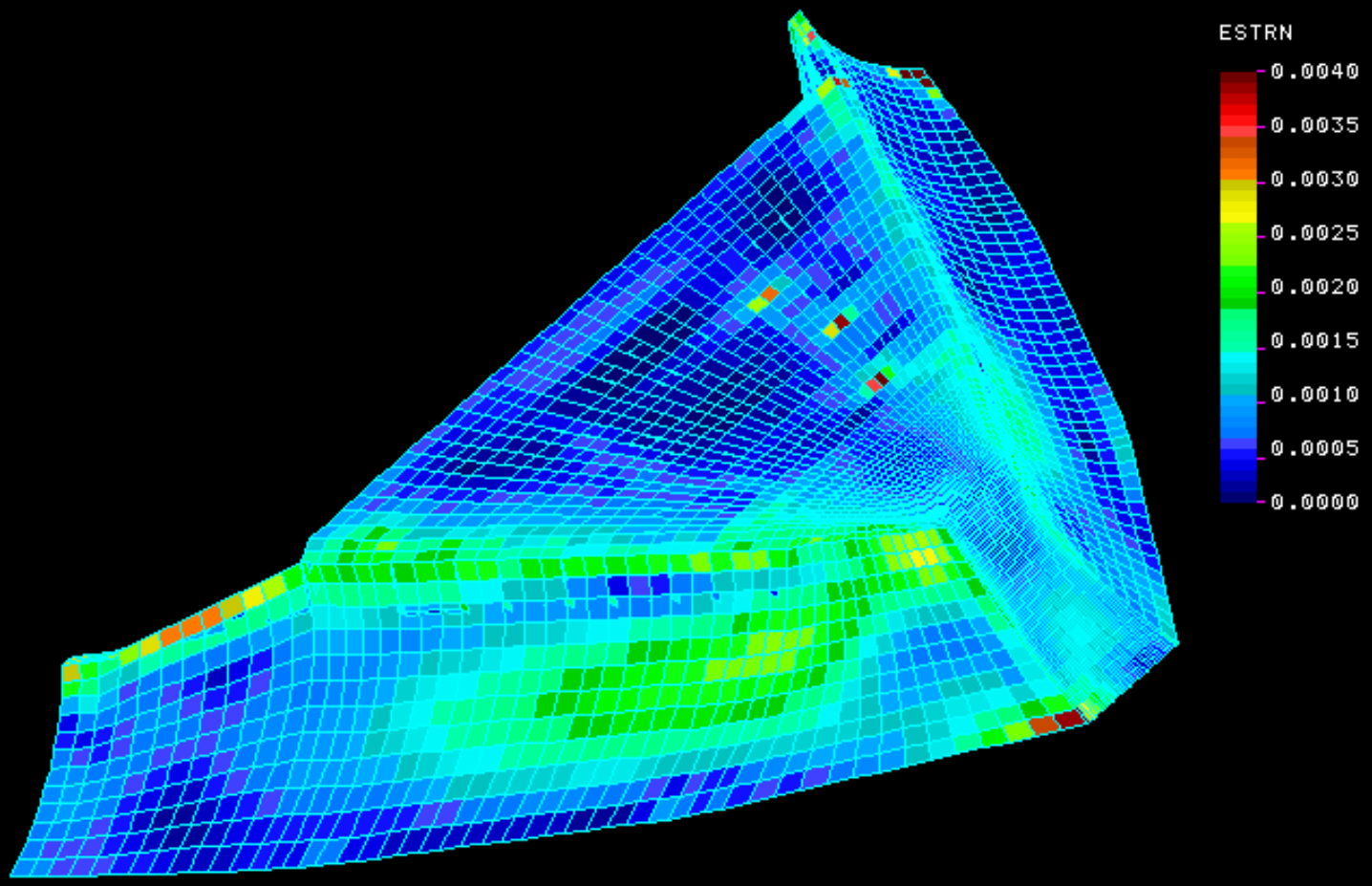
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LC10- GMT- Transverse Loading
Vertical Displacement



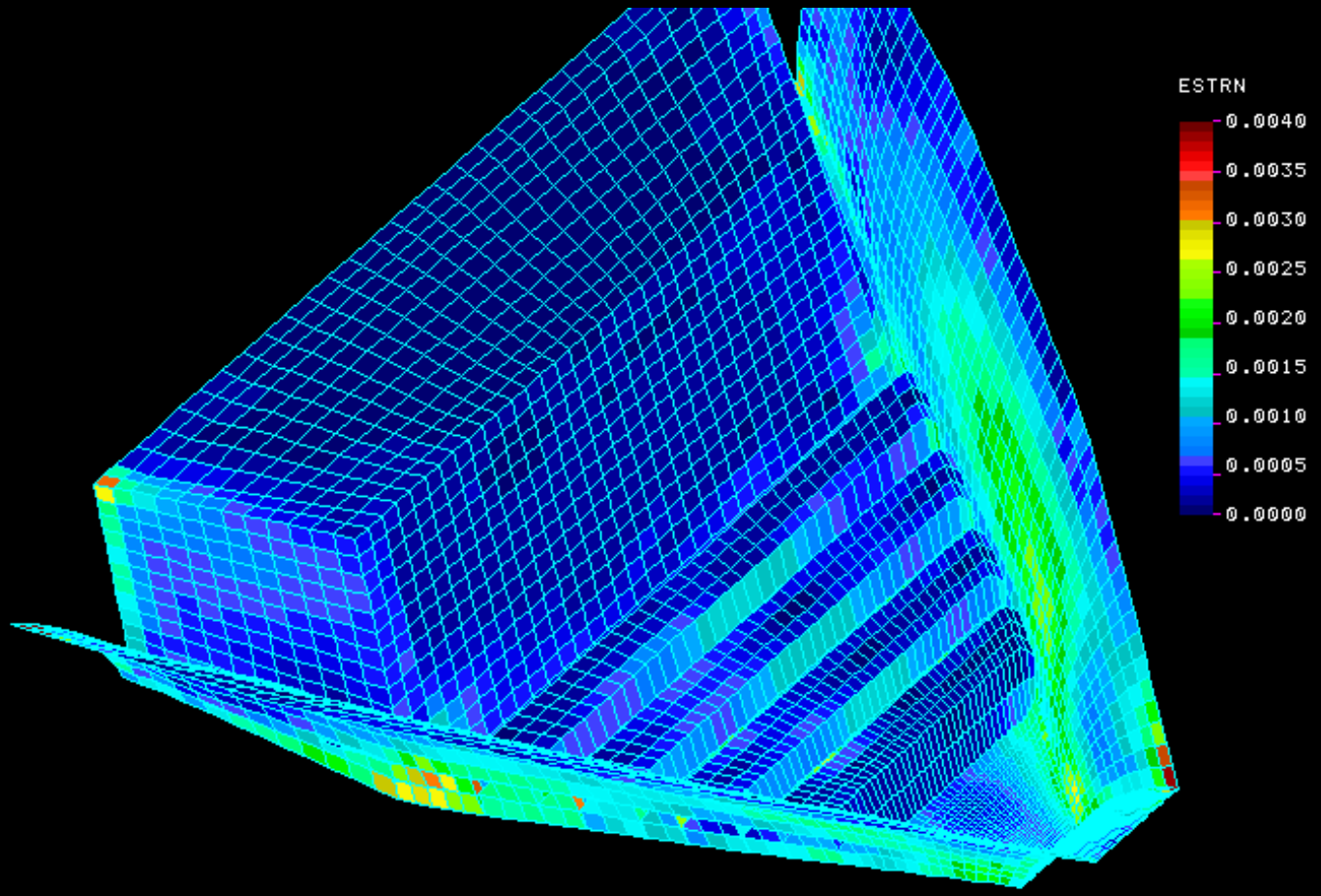
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LC10- GMT- Transverse Loading 1st Layer Strain (Outside View)



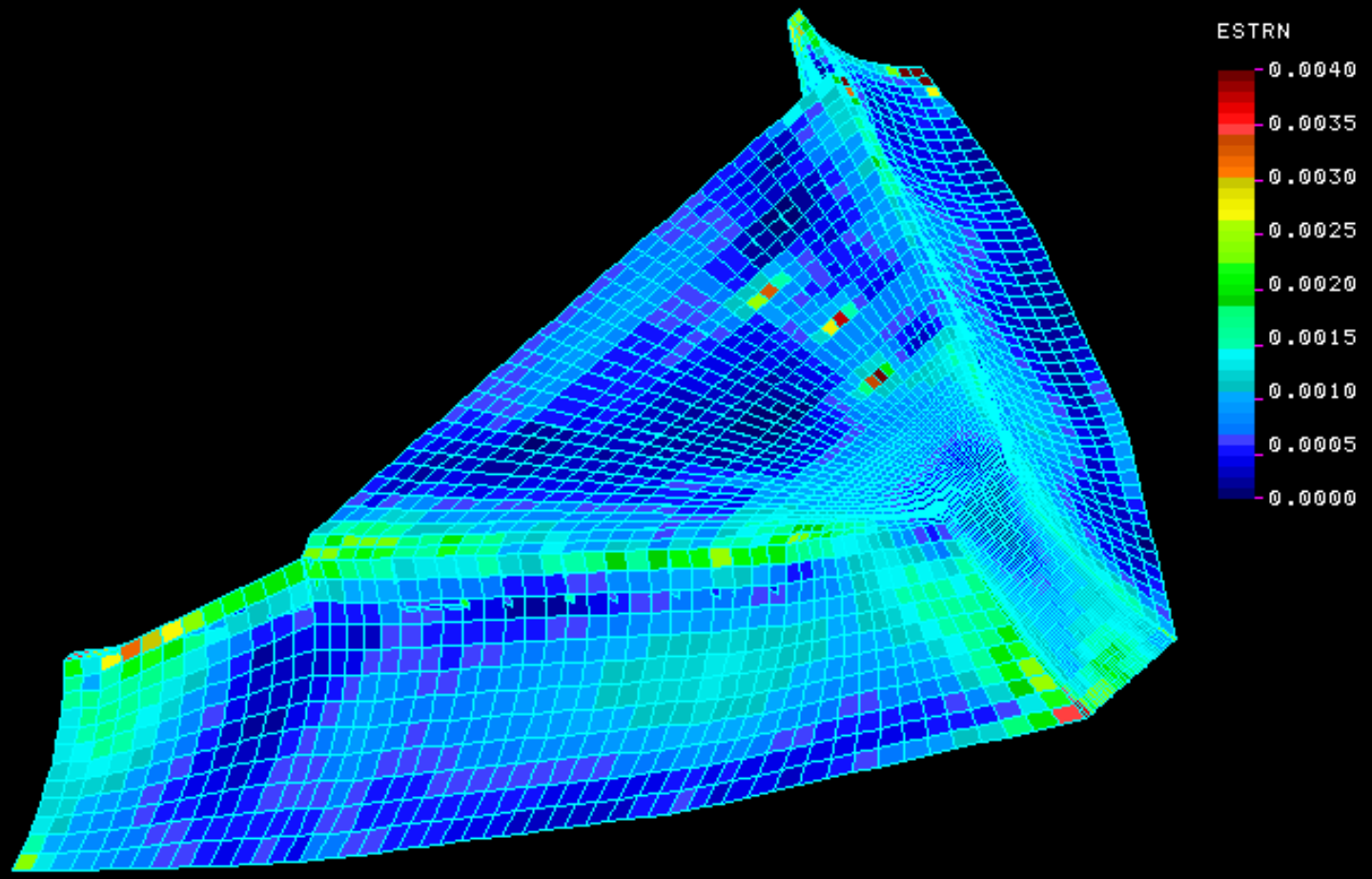
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LC10- GMT- Transverse Loading 1st Layer Strain (Inside View)



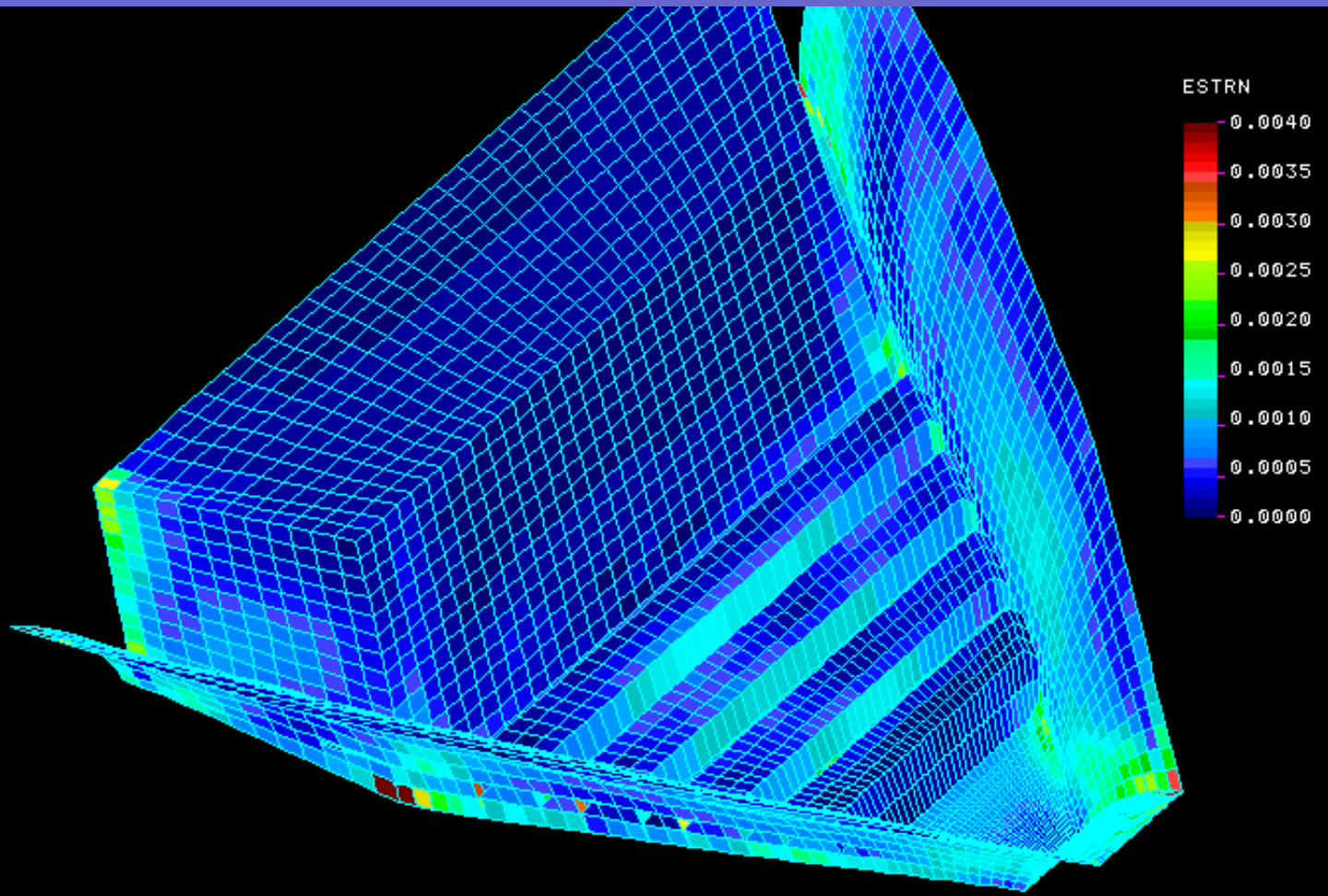
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LC10- GMT- Transverse Loading
Last Layer Strain (Outside View)



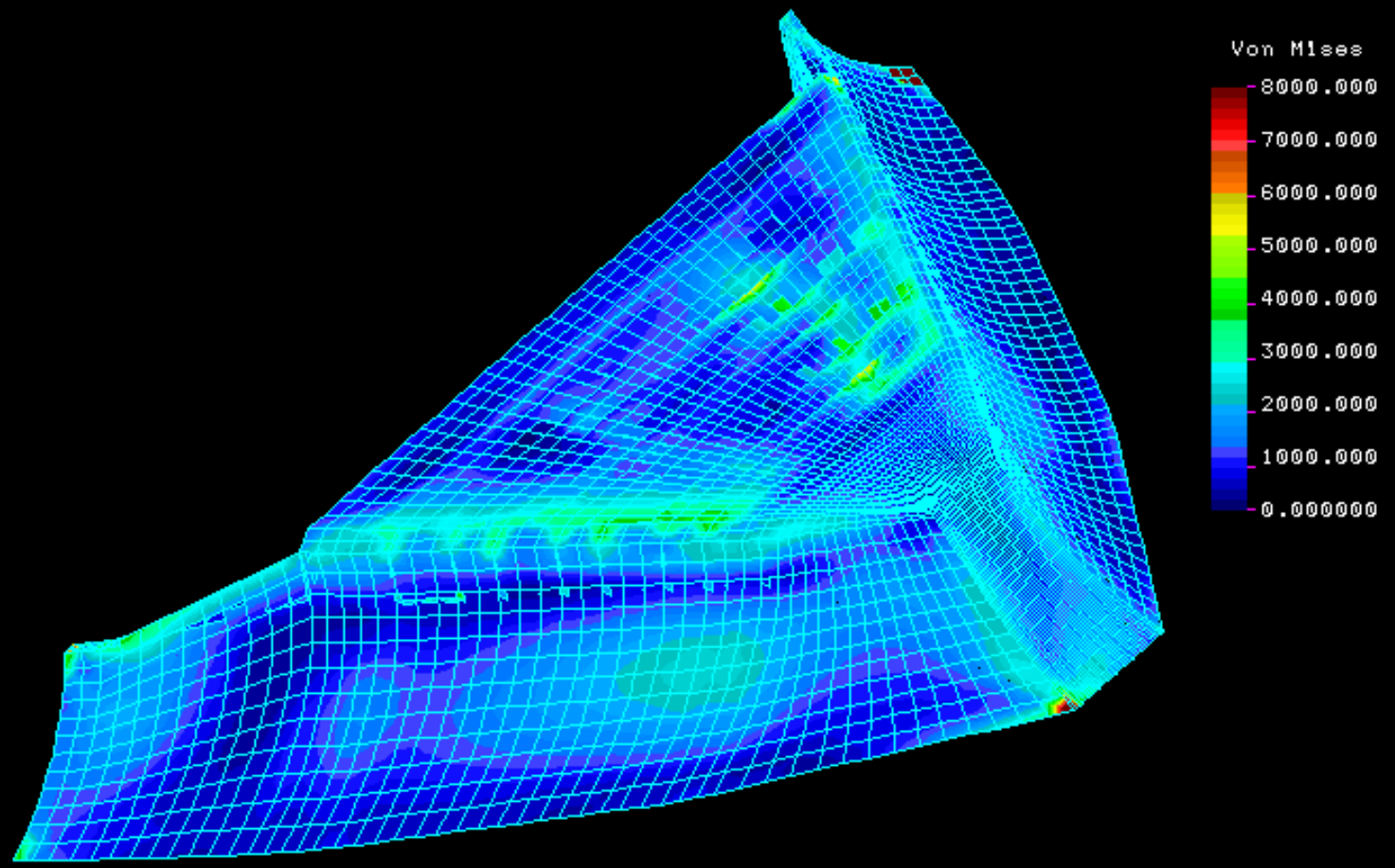
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LC10- GMT- Transverse Loading
Last Layer Strain (Inside View)



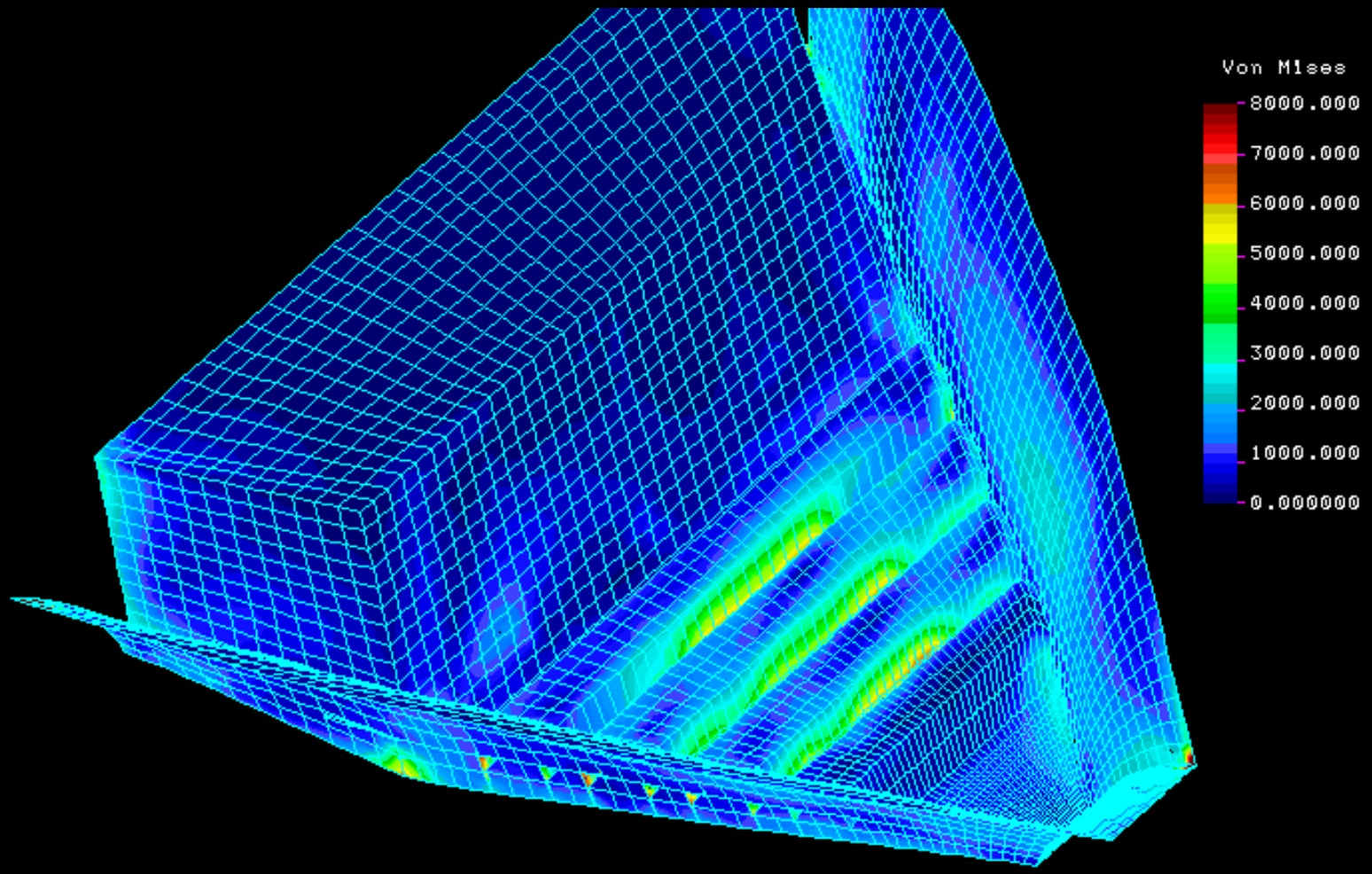
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LC10- GMT- Transverse Loading
Longitudinal Ply Stress (Outside View)



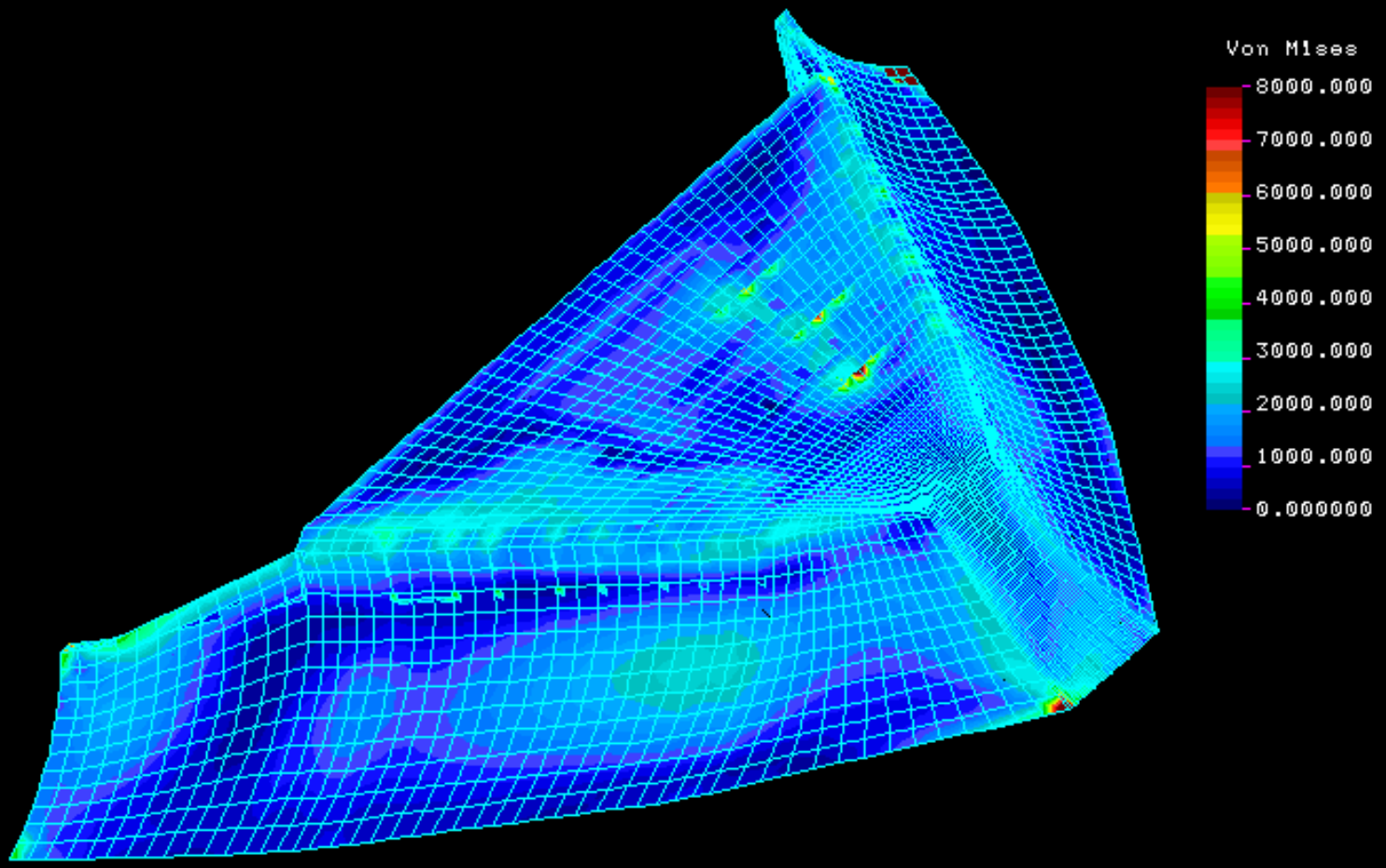
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LC10- GMT- Transverse Loading
Longitudinal Ply Stress (Inside View)



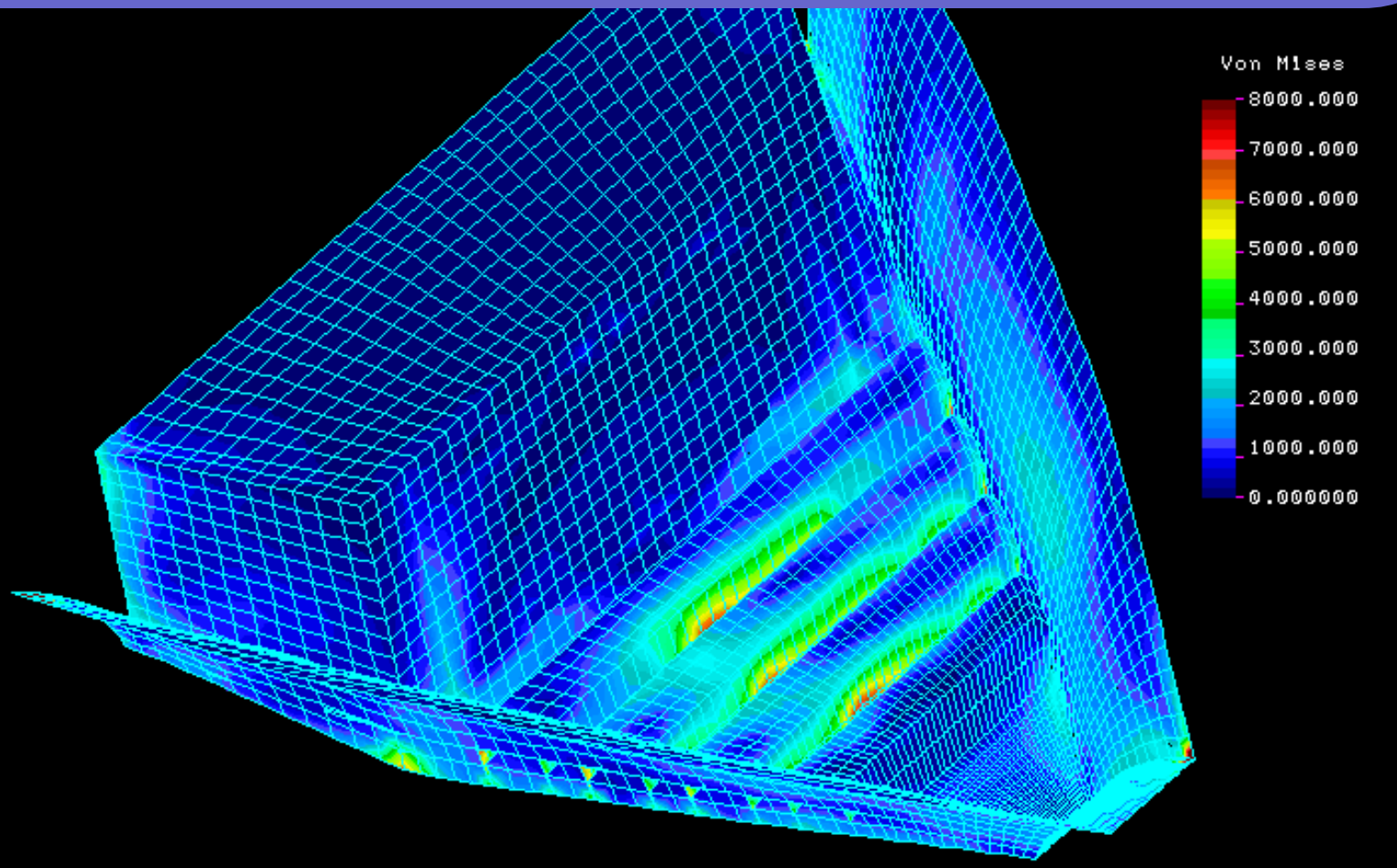
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LC10- GMT- Transverse Loading
Transverse Ply Stresses (Outside View)



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LC10- GMLT- Transverse Loading
Transverse Ply Stress (Inside View)



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LC10- G.M.T- Summary

- Range of deflection -0.25 - 0.18 in.
- Maximum strain 0.004 in./in.
- Maximum longitudinal stress 6,000 psi
- Maximum transverse stress 8,000 psi

179

11M- FEA Analysis:
Trailer Load Analysis (TLA)
Fiberglass Design

















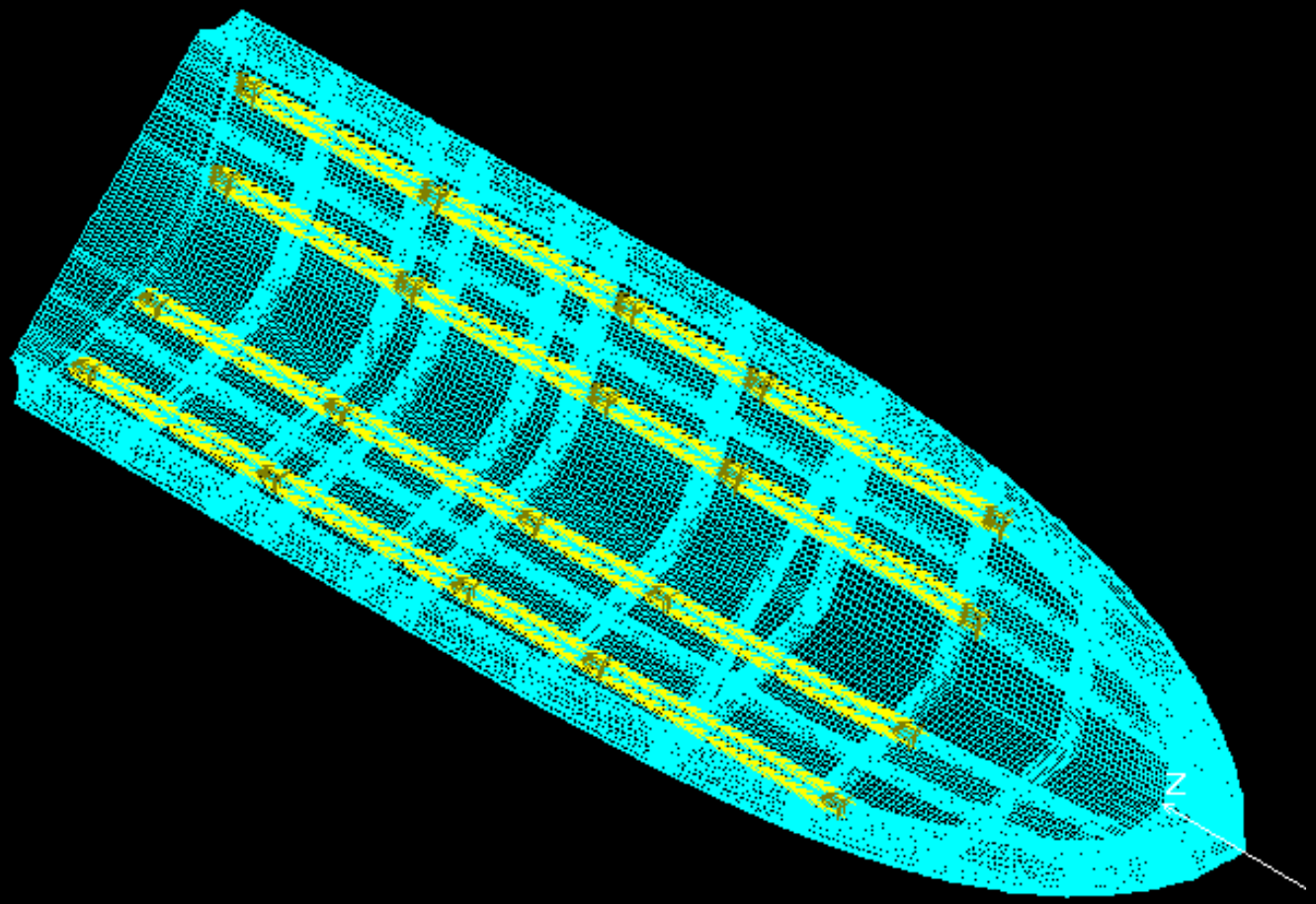




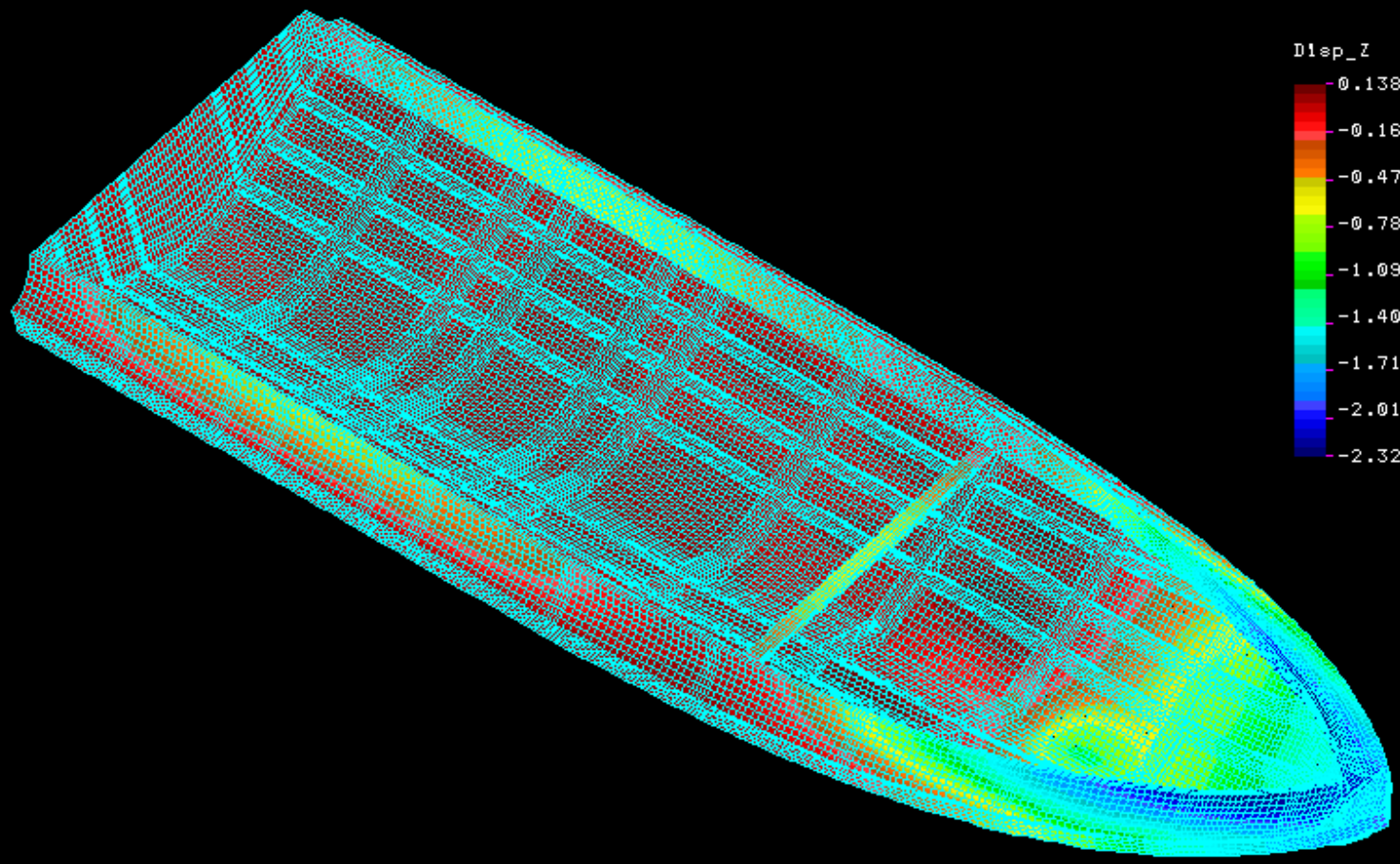
LC8-FG- Trailer Loads Applied

- 3G vertical acceleration (51,000 lbs)
- Weight is uniformly distributed over boat (-1.06 lbs on each node = -51,000 lbs
- Boat is supported by 4 bunks, located under inner and outer stringers on each side
- Bunk support modeled as vertical force applied along bottom side of stringer frames (50 lbs on each of 1008 nodes for 50,400 lbs)
- Bunk supports modeled s vertical constraints (600 lbs total reaction)

LC8-FG - Trailer Loads- Bunk and Loading Constraints

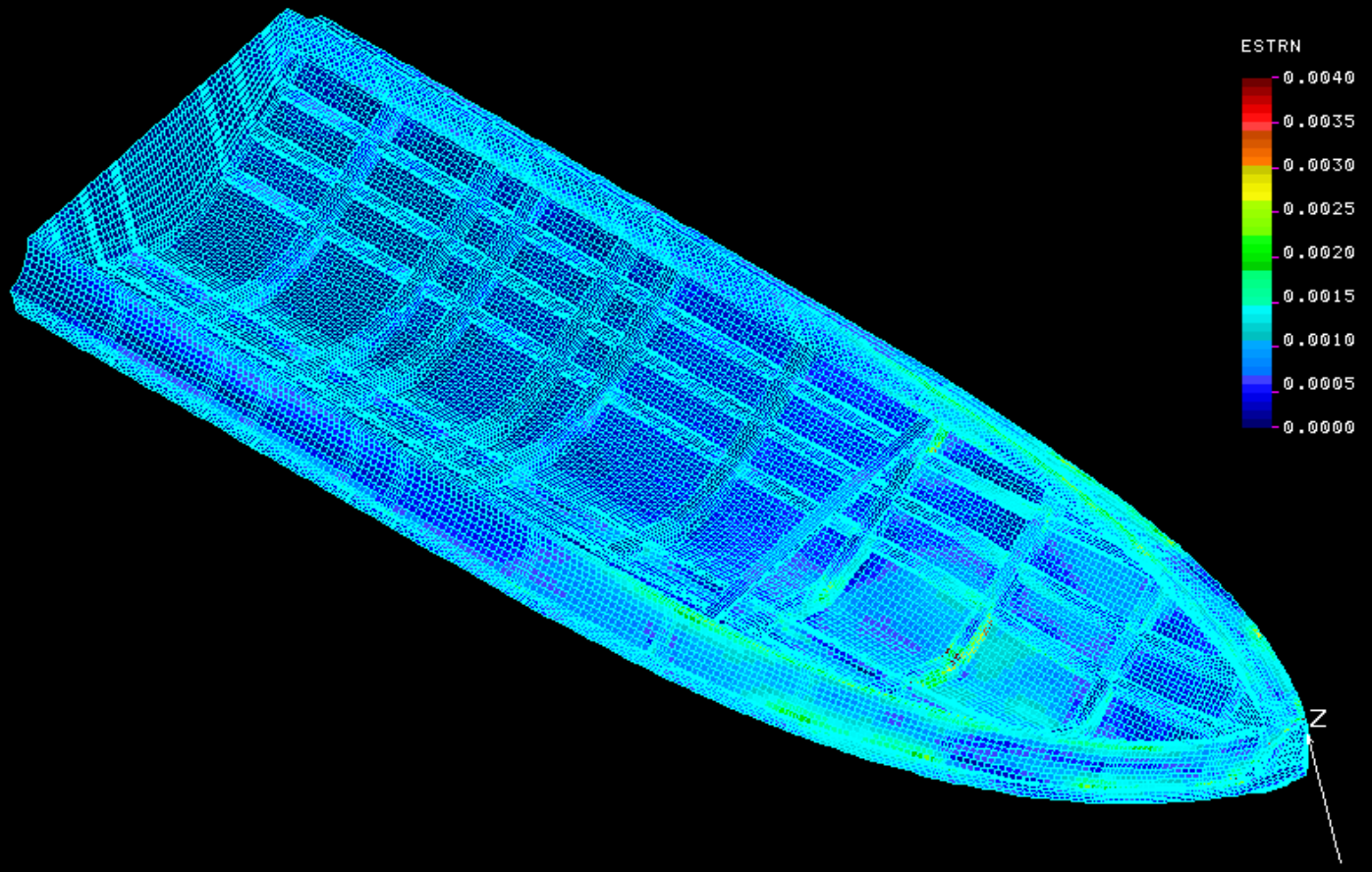


LC8-FG- TLA- Trailer Loads Vertical Displacement



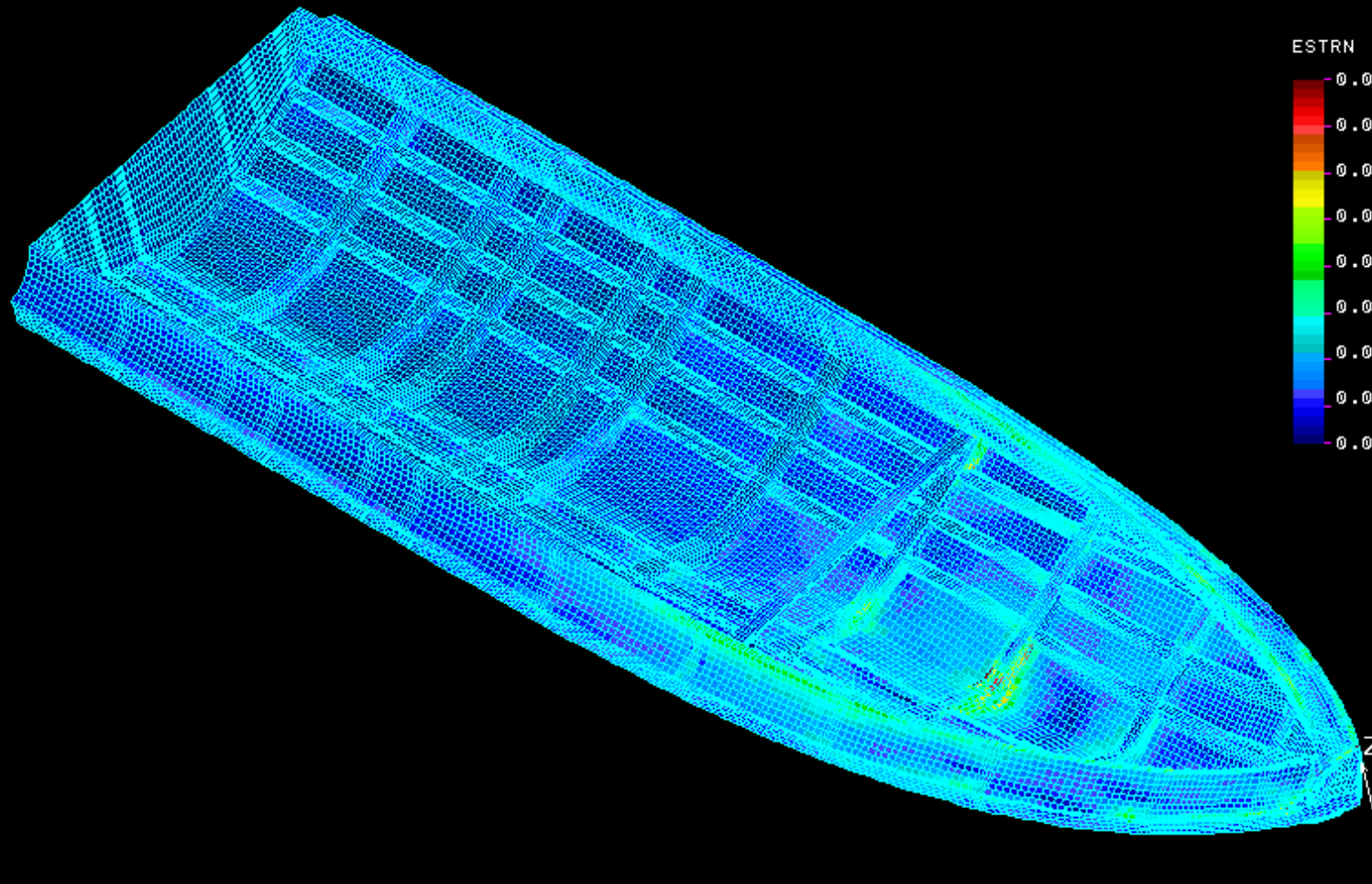
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LC8-FG- TLA- Trailer Loads
Outside Surface Strain



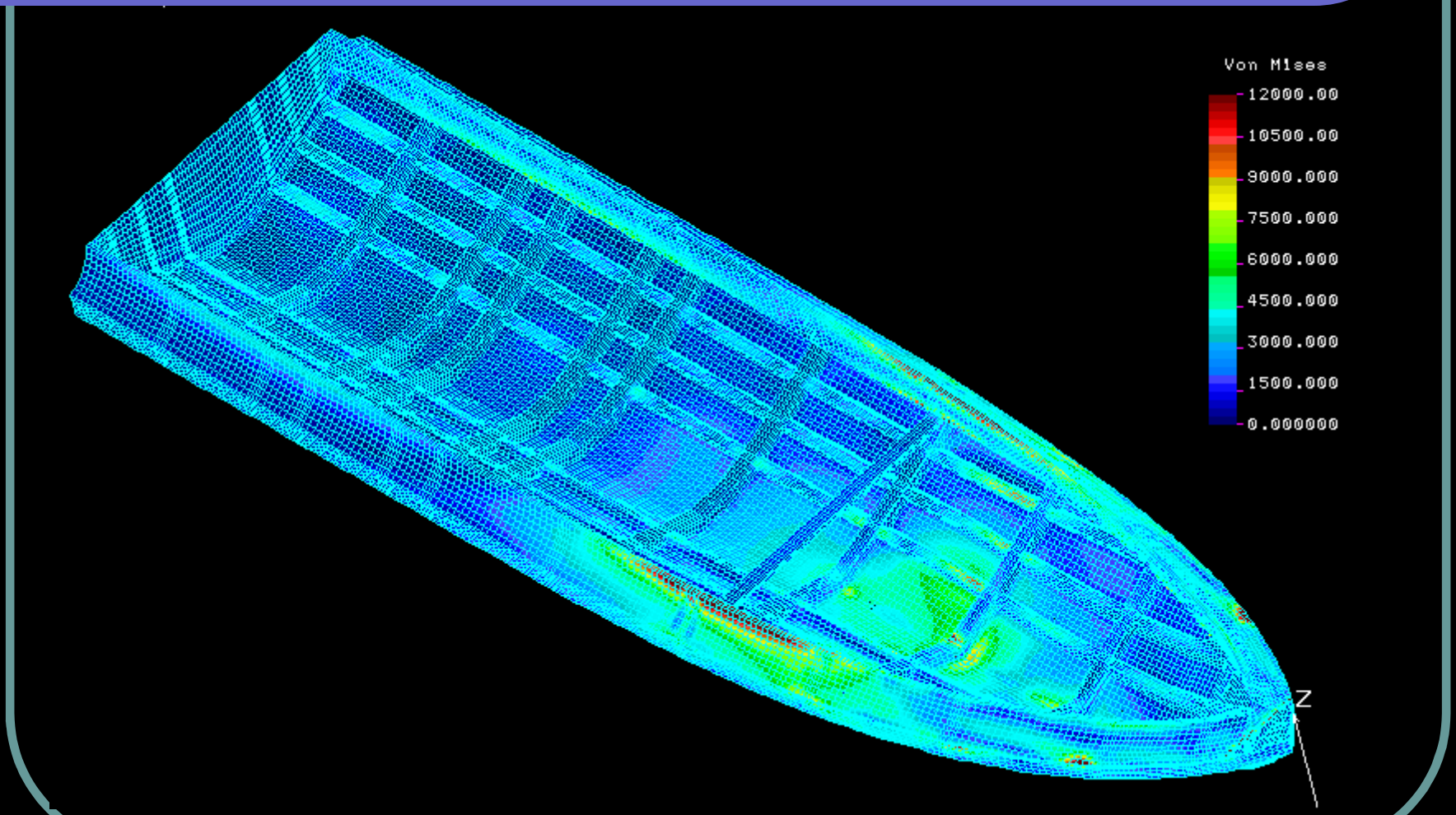
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LC8-FG - TLA- Trailer Loads
Inside Surface Strain



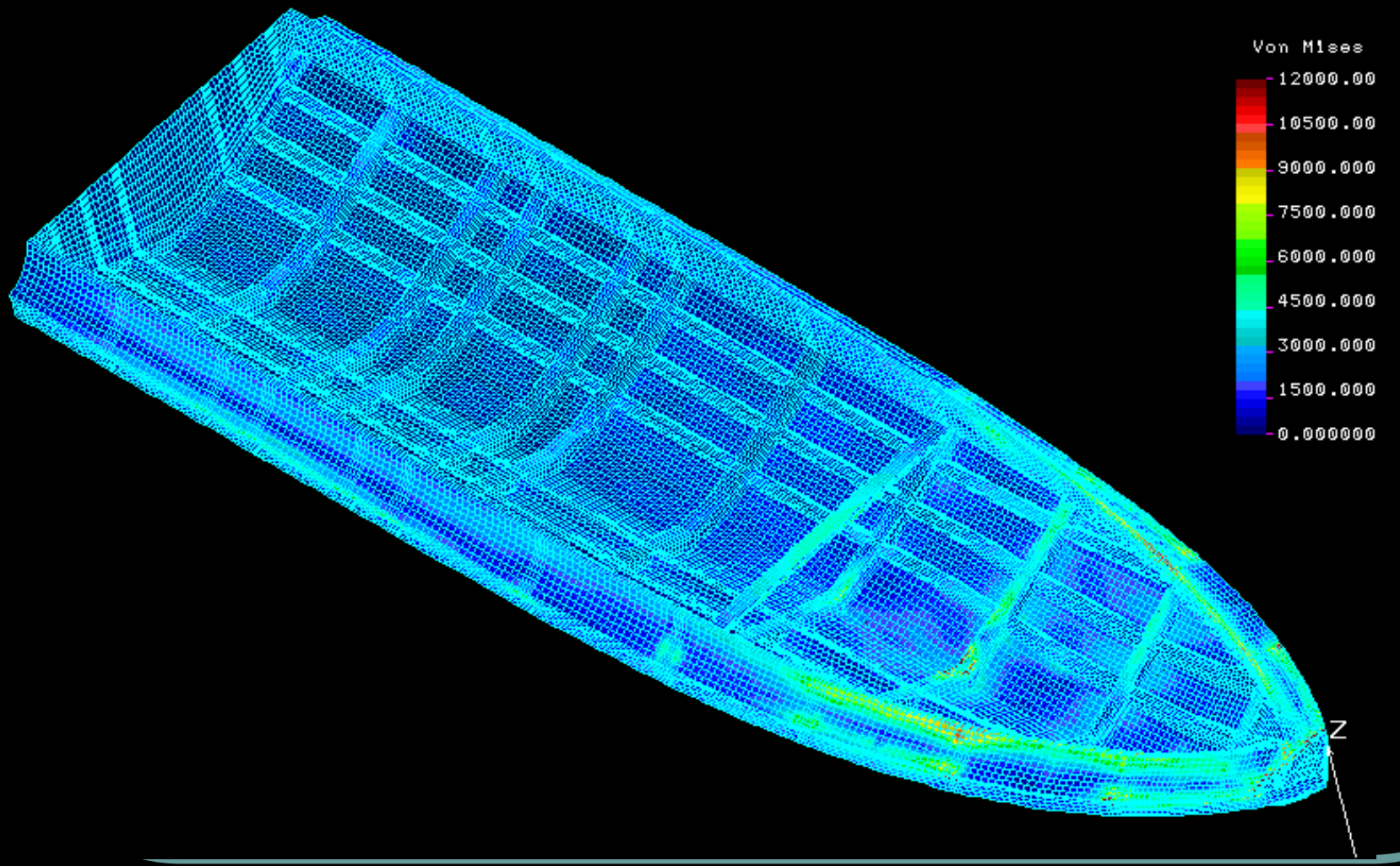
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LC8-FG - TLA- Trailer Loads Longitudinal Stress



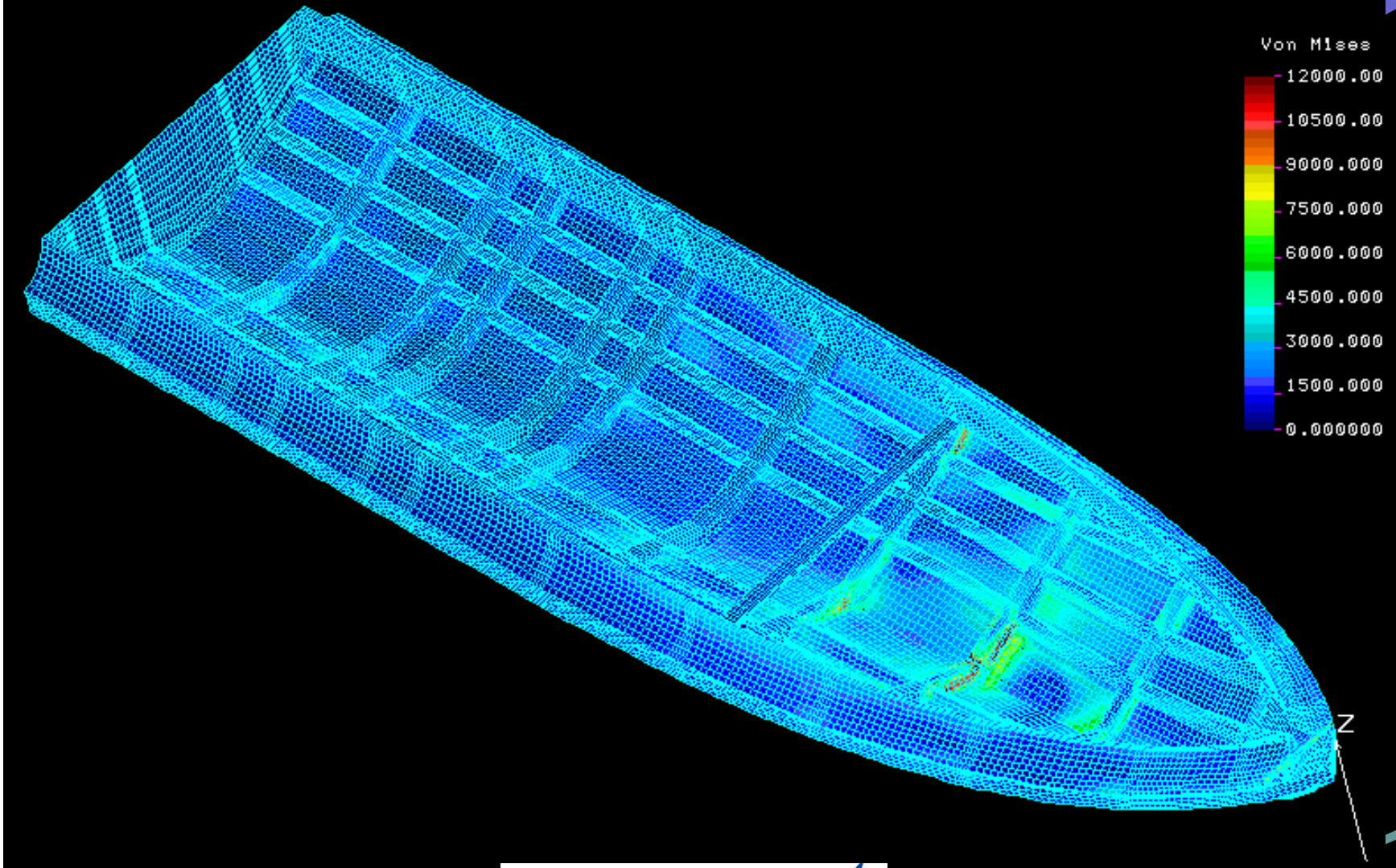
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LC8-FG - TLA- Trailer Loads Transverse Stress



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LC8-FG - TLA- Trailer Loads



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LC8-FG TLA- Summary

- Hull range of deflection -2.3 to 0.14 in.
- Maximum Hull strain 0.004 in/in
- Maximum framing stress 15,000 psi

LC8-FG- TLA Summary

- Structural Analysis for 3 G “hit” while traveling on trailer
- Stresses and strains are low except at the forward end of the support bunk, where a minimum safety factor of 8 (i.e. a 24 G acceleration is required to break the boat structure)

Weight Evaluation Advanced and FG

Component	AL – Weight (lb)	FG – Weight (lb)
Hull	930-960	1070-1100
Deck	470-490	470-490

Total Weight Hull and Deck	**1400-1450 55% to 57% Savings from Baseline**	**1540 - 1590 50 to 53% Savings from Baseline**

Weight Evaluation FG Fiberglass Laminate

Component	Weight (lb)
Hull	1070-1100
Deck	470-490

Total Weight Hull and Deck Fiberglass Hull Laminate	**1540 - 1590 50 to 53% Savings from Baseline**

Preliminary Design Summary

- Framing and Laminate Schedule
  - Indications are the laminates are adequate
- Weight Evaluation
  - 11M- Exceeds Metrics, On Target

11M Conclusions

- Both Advanced and Fiberglass designs are adequate
- Both Designs Exceed Weight Reduction Goal
- Fiberglass Design Chosen For Rapid Implementation- Lower Risk
- Advanced Design recommended if Navy Desires to advance new materials- Higher Risk